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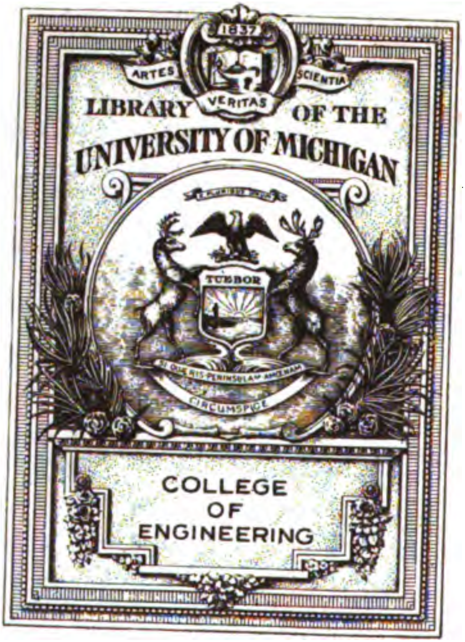

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Electrical Equipment of the Motor Car

By D. P. Moreton and D. S. Hatch

THE electrical equipment of the modern motor plays such an important part in the satisfactory operation of the car and the degree of comfort given the owner that it requires a great deal more consideration at the present time than ever before. Both owner and repairman are eager to know more about the operation of the electrical equipment and with this requirement in mind the manuscript for the "Electrical Equipment of the Motor Car" was prepared. Special attention has been given to a thorough and practical treatment of the fundamental principles of electrical engineering as applied to the electrical equipment found on the modern motor car. If these fundamental principles are well understood it is a comparatively easy task to trace out and locate all cases of electrical trouble in a very definite and systematic way.

The book is well illustrated and numerous special diagrams have been prepared to bring home more forcefully the subject matter under discussion.

Contents by Chapters

1—Fundamentals of Electrical Circuit: 2—The Series Circuit: 3—Parallel Circuits: 4—Making Electricity Do Work: 5—Electrical Power: 6—Primary Batteries: 7 Storage Batteries: 8—Care of Storage Batteries: 9—Magnets and Magnetism: 10—Electromagnetism: 11—Electromagnetic Induction: 12—Generators and Motors: 13—Fields and Windings for Generators and Motors: 14—Generator Output and Purpose of Cutout: 15—Regulation of Generator Output: 16—Electric Motors: 17—Motor and Engine Connection: 18—Switches and Protective Devices: 19—Electric Lamps: 20—Electrical Instruments: 21—Ignition Systems: 22—The Magneto: 23—Battery Generator Ignition: 24—Spark Plugs: 25—Ignition Wiring and Timing: 26—Electric Signals and Accessories: 27—Electric Gearshifts and Transmissions.
1915 to 1920.

768 Pages, 5x7 Inches, 428 Figures, 257 Blueprint Wiring Diagrams. Flexible Fabrikoid to match this book. Price $3.50 Delivered.

Automobile Electrical Systems

An Analysis of All the Systems Now Used on Motor Cars with 200 Wiring Diagrams and Giving Special Attention to Trouble Shooting and Repairs.

BY

David Penn Moreton
and Darwin S. Hatch

NEW YORK
U. P. C. BOOK COMPANY, INC.
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1921

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PREFACE

This volume has been prepared to meet the demands of car owners and repairmen who wish to know the installations, operation and repair of all of the various ignition, starting and lighting systems. The authors have assumed that the readers have a working knowledge of the fundamental principles of the electrical circuit and the entire book is devoted to a discussion of the various systems. The readers wishing a thorough treatment of the fundamental principles of electricity and their applications to the motor car are referred to the Authors' book entitled, "Electrical Equipment of the Motor Car," published by the U. P. C. Book Company, Inc.

Chapter I is devoted to a general discussion of wiring diagrams and the proper method of tracing the various electrical circuits as shown in the diagram. A thorough understanding of a wiring diagram and a careful analysis of a case of electrical trouble will in the majority of cases enable one to locate the cause of the trouble quite definitely.

Chapter II is devoted to the electrical equipment on the model T Ford previous to the installation of the F. A. starting and lighting system.

Chapters III to XVIII inclusive are devoted to special starting, lighting and ignition systems for the Ford car, such as Gray and Davis, Westinghouse, Heinze-Springfield, Everready, Genemotor, Disco, Fisher, Splitdorf, Dyneto, North East, Genolite, Hendricks, Kemco, Atwater Kent, Dixie, Bosch, Vibrator-Les, and Philbrin.

Chapters XIX to XXXVI inclusive are devoted to a complete analysis of the following starting, lighting and ignition systems. Auto-Lite, Delco, North East, Wagner, Bijur, Remy, Simms-Huff, Westinghouse, Gray and Devis, U. S. L., Leece-Neville, Bosch-Rushmore, Dyneto, Heinze, Allis-Chalmers, Disco and Ward Leonard.

Chapter XXXVIII is devoted to "Maintenance and Repair of

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Electrical Equipment and how to Diagnose Electrical Troubles." This chapter is divided into four parts as follows: Part I treats of the general points of maintenance, such as soldering and taping points, care of generators and motors, care of storage batteries and adjustment of cutouts. Part II treats of the testing equipment such as lamps, ammeters, voltmeters, etc. Part III gives a general classification of electrical troubles and simple practical tests for locating same. Part IV gives the method of procedure in testing out a complete electrical system.

Chapter XXXVIII is devoted to a complete description of the F. A. starting and lighting system for the Ford car. Particular attention is given to the methods of testing and locating faults in the system.

Numerous special wiring diagrams are given throughout the book which have been specially prepared so as to illustrate the actual installation of the electrical equipment in a clear and simple manner.

A number of special electrical specification tables have been prepared to assist the readers in readily determining the nature of the electrical system used on any car together with the details of that system. These tables will enable the owner or repairman to pick out the correct lamp, fuse, etc., for each system, thus eliminating all guess work or improper substitutions.

May, 1920.

DAVID PENN MORETON.

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CHAPTER I

Reading Wiring Diagrams

INDIVIDUAL systems of starting, lighting and ignition for motor cars as manufactured by the various companies vary considerably in detail, and the component parts of the same type and make of system are often of different construction when used on cars of different make, but in principle all are alike.

Every standard starting, lighting and ignition system must include the four following important component parts:

1—The generator.

2—The storage battery.

3—The electric motor.

4—A means of producing the spark in the engine cylinders.

The function of these component parts are:

The generator is connected mechanically to the engine and when its armature is made to rotate by the engine, a part of the mechanical energy of the engine, or its ability to do work, is transformed into electrical energy and the electrical energy which is delivered by the generator may be used in charging the storage battery, in lighting the lamps, operating an electric heater, producing the spark in the engine cylinders, etc.

The storage battery serves as a means of storing energy while it is available from the generator and then delivering it at such time as it may be called upon to do so. Thus, while the engine is operating the generator and the generator is capable of delivering electrical energy, this energy may be stored in the battery and then delivered to the starting motor, lights, ignition system, etc., as conditions may demand.

The electric motor is a device for transforming electrical energy into mechanical energy which may be used in cranking the engine. The electrical energy supplied by the storage battery when it is allowed to discharge through the starting motor circuit thus is utilized in starting the engine.

The ignition device transforms electrical energy, which may be supplied by the storage battery, dry battery or magneto, into heat energy in the spark in the engine cylinders and thus produce the explosion of the gases and cause the engine to operate.

In addition to the four component parts given, various additional parts, such as wires, switches, connectors, ammeters, voltmeters, fuses, circuit-breakers, automatic current and voltage regulators, etc., are necessary for the convenient and safe operation of the four main component parts.

Wiring Diagrams and Symbols

All manufacturers of electrical equipment supply wiring diagrams which show the proper connections of their apparatus. Such wiring diagrams often permit a circuit to be traced much more easily than is possible if the actual wires on the car have to be followed through. Consequently the ability to read a wiring diagram is essential in locating troubles in circuits.

Certain conventional symbols have come to be used almost universally in wiring diagrams to represent the different pieces of apparatus and their connections. These are shorthand pictures of the thing represented. They are not all standard, but some of them, such as the symbols for the ground connection and the battery, are standard. Lamps, for instance, may be represented by a circle, a bulb, or the complete lamp assembly.

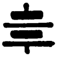
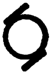
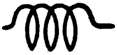
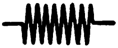
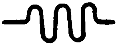
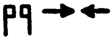
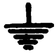
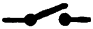
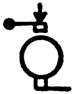
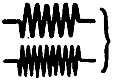
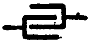
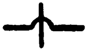
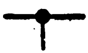
The more usual symbols are illustrated on the facing page.

A Typical Installation

Before taking up the individual systems we will take up an assumed system which is typical of all the common installations on modern cars. In this, illustrated in Figs. 1, 2 and 3, the sidelights are incorporated with the headlights, there being two bulbs in each headlight, one low candlepower and one high candlepower. Lights and horn are connected through a main switch on the cowl.

Some means of connecting and disconnecting the generator and battery is provided in the majority of cases to prevent a discharge of the batteries through the generator when the voltage of the generator is lower than the voltage of the battery.

Conventional Wiring Symbols

+	Positive.
−	Negative.
	Battery, either storage or dry cells.
	Generator, Commutator and Brushes.
	The proper method of showing a coil which surrounds an iron core but very seldom used on Delco Drawings.
	The method used in showing a coil where there is no chance of confusion—Used in field coils, ignition coils, etc.
	The method used to show resistance such as a resistance unit and charging resistances.
	Contact points such as in switches, distributors, etc.
	Ground connection where the wire is connected to the chassis, engine or generator.
	Method used to show lighting switches.
	Motor Commutator and brushes with brush lifting switch.
	Primary and secondary windings of an ignition coil.
	Condenser.
	Crossed wires not connected.
	A round dot on a circuit diagram usually represents a terminal for connecting a wire or wires.

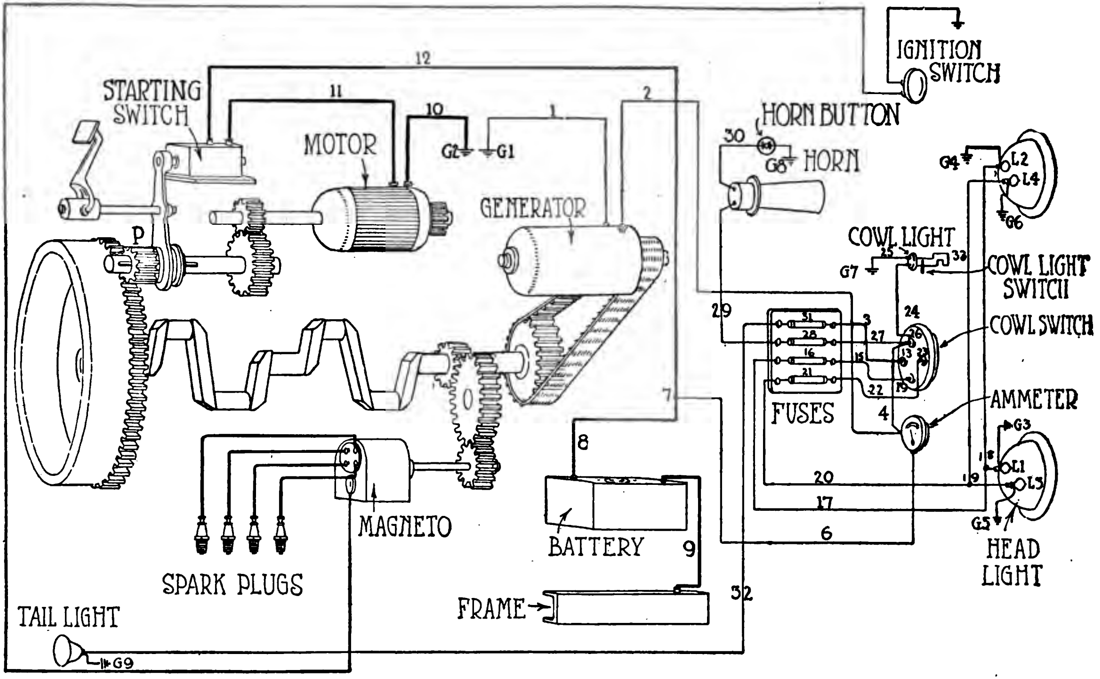


Fig. 1—Mechanical and electrical connections of a typical three-unit single-wire starting, lighting and ignition system. In Fig. 2 the actual location of these units and course of the wires are shown. In Fig. 3 the wiring diagram of this system, is illustrated

This device is called a cut-out and it has been omitted from the diagrams, for the sake of clearness.

Tracing the Circuit

The generator in this case is connected to the engine shaft by a silent chain, and the circuit through which the generator sends the charging current for the storage battery may be traced in Figs. 1, 2 or 3 as follows: Starting with the ground connection G1, you follow along the wire 1, through the generator along wire 2, through the ammeter, along wire 6 to junction point 7, then along wire 8 to the battery, through the battery and along wire 9 to the frame of the car, which is the same as the ground connection G1, from which you started, since all indicated ground connections are in reality connections to the frame, and in such cases the electrical circuit is completed through the chassis.

It sometimes is difficult to determine from a wiring diagram or from the wires themselves on a car just which of two or more wires at a junction are taking the current. This always can be ascertained by remembering that current will flow only where there is a complete circuit, for instance, in the circuit just mentioned all the switches are open, except the connection between the generator and battery, and that therefore is the only complete circuit. Consequently when we come to the junction of the two wires at the ammeter we know that no current is going up on wire 4 to terminal 26 on the cowl switch because this switch is open, and the horn button and the cowl light switch 33 are open so that there is no connection to any circuits out of the switch. Likewise when we come to junction point 7 we know that all the current must pass down through wire 8, and none through wire 12, because the starting switch is open.

The ignition in this case is provided by a high-tension magneto driven from the engine shaft by gears. The ignition circuit is not shown in detail but it is controlled by the ignition switch shown in the upper right-hand corner.

The motor circuit may be traced in a similar manner by starting with the ground connection G2. You follow along the wire 10, through the motor along the wire 11 to the starting switch, through the starting switch, when it is closed, along the wire 12 to the junction point 7, along the wire 8, through the battery, along the wire 9 to the frame of the car, which is the same as the ground connection G2, from which you started. The motor switch in this case is operated by pressing on a pedal, which also causes a pinion P on the motor shaft connection to engage with a gear on the flywheel and thus establish a mechanical connection between the motor and the engine shaft. This mechanical connection between the engine and the motor is maintained and the electrical circuit through the motor and battery remains closed as long as the pedal is pressed down.

The electrical circuit for the low-candlepower headlights, when they are operating off the storage batteries, may be traced as follows: Starting with the frame of the car or grounded terminal of the battery you pass along wire 9, through the battery and along wire 8 to junction point 7, then along wire 6 through the ammeter along wire 4 to terminal 26 of the cowl switch, then from terminal 14, when the switch is closed, along wire 15 through fuse 16, along wire 17 to the junction point 18, where the circuit divides, part of the current passing through bulb L1 to ground G3 and part through bulb L2 to ground G4. The ground connections G3 and G4 are the same as the point from which you started. The circuit for the high-candlepower headlight is the same as that for low-candlepower lights up to terminal 26, then with switch thrown to terminal 23 you pass along wire 22, through 21, along wire 20 to junction point 19, where circuit divides, part of current going through bulb L3 to ground G5 and part through L4 to ground G6. It will be observed that this last circuit was traced through the battery in the opposite direction to that of the generator and motor circuits, but the results are just the same except in one case you will follow along the circuit in the direction of the current and in the other case in the opposite direction. In each case you must return to the point from which you started.

The circuit for the cowl light is the same as the headlights up to switch terminal 26, then along wire 24 through the cowl light switch 33 and bulb along wire 25 to the ground connection G7. The circuit for the horn is the same as that for the headlights up to terminal 26 on the cowl switch, then along wire 27 through fuse 28, along wire 29 and through the horn along wire 30 through the horn button when it is closed to the ground connection G8.

The circuit for the tail light may be traced as follows: From the frame of the car along wire 9 through the battery along wire 8 to the junction point 7 along wire 6 through the ammeter along wire 4 to terminal 26 to terminal 13 when switch is closed through wire 3 through the fuse 31 along wire 32 through the taillight and to the ground connection G9.

Assuming the generator is not charging the battery and that all lights are turned on and the horn button is closed, determine the current in the different wires. Wires 9, 8 and 6 will be carrying the total current supplied by the battery. The current in wire 12 will be zero, since the motor switch is open, so that the current through the ammeter is that taken by the large and small headlights, horn, taillight and cowl light. Wires 4, 3 and 32 carry the current for the taillight. Wire 4 carries the current taken by the horn, headlight, taillight and cowl light. Wires 27, 29 and 30 carry the current taken by the horn. Wires 15 and 17 carry the current taken by the low-candlepower headlights. Wires 20 and 22 carry the current taken by the high-candlepower headlights. If the motor switch is closed, the current in wires 8 and 9 will be equal to the current supplied by the battery, and wires 10, 11 and 12 will carry the motor current.

Assuming the motor circuit open and all the other circuits closed and the generator delivering current, if the current delivered by the generator is just equal to the current taken by the horn, taillight, cowl light and headlights, there will be no current in the ammeter. If the current delivered by the generator exceeds in value the current taken by the horn, tail, cowl and headlights, the current in the ammeter will be toward junction point 7, and the ammeter will show charge. Should the value of the generator current exceed that of the combined currents taken by the horn, taillight, cowl light and headlights, a charging current will be sent along wires 6, 8 and 9. When all the lamps and horn are disconnected, all current supplied by the generator passes through the battery. If the terminal voltage of the generator is lower than the terminal voltage of the battery, then the battery will supply current to all the lamps and horn and in addition send a current through the generator, unless the connection between the generator and battery is broken by some form of cut-out, and the generator will tend to operate as a motor. When the battery is supplying current through the lights or horn the ammeter will show discharge.

The reader must bear in mind always that every electrical circuit is just like a circle. It has neither beginning nor end. It is absolutely imperative that you be able to trace the various

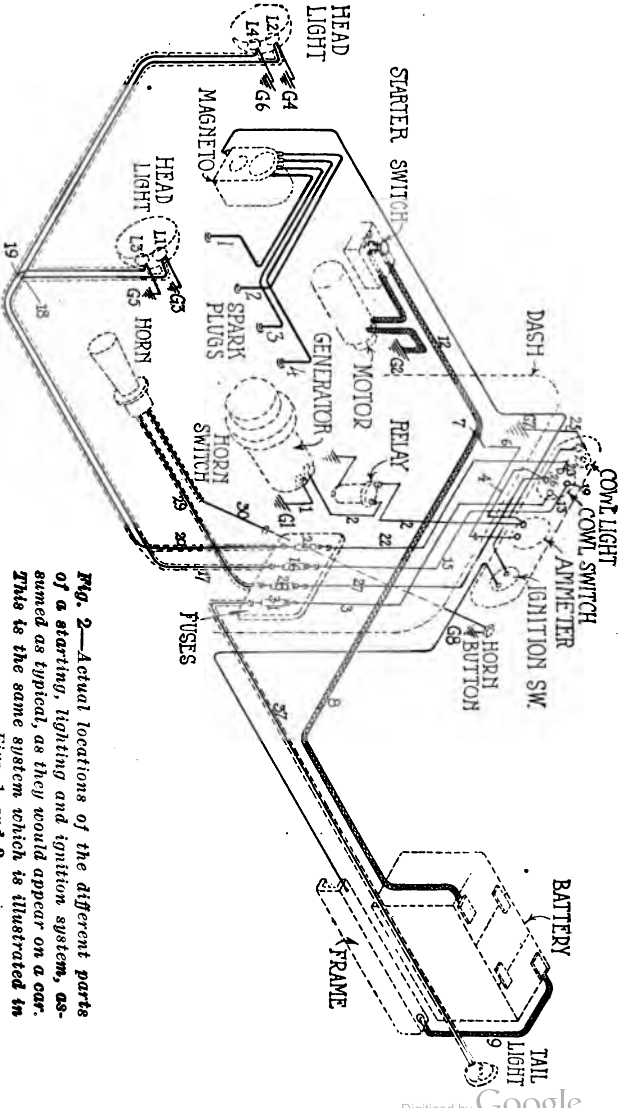


Fig. 2—*Actual locations of the different parts of a starting, lighting and ignition system, assumed as typical, as they would appear on a car. This is the same system which is illustrated in Figs 1 and 3*

electrical circuits on the motor car to clearly understand their operation and know how to test and locate readily the various causes of trouble which are likely to arise. Always bear in mind that electricity is not used up and just as much returns to the generator or battery as leaves it. It is the energy, or ability to do work, possessed by the electricity when it leaves the generator or battery when the battery is discharging which is used in the electrical circuit.

Using a Wiring Diagram

The primary purpose of every wiring diagram of a starting, lighting or ignition system is to show the proper electrical connections between the various devices which go to make up the complete systems. These wiring diagrams are often quite a puzzle to the inexperienced man, and also to the man who has not taken time to give these the necessary consideration in connection with the installation, maintenance or repair of the different systems which he has worked upon.

One of the chief reasons why a wiring diagram is of no real assistance to the majority of men working on the electrical equipment of motor cars is due to their lack of a clear conception of the proper operation of the various electrical circuits which go to make up the complete systems. Another, and almost equally important reason, is the lack of sufficient imagination to follow along the various electrical circuits just as though the wires and different devices were suspended in space and absolutely independent of all other parts of the car. The relations of the component parts of a starting, lighting and ignition system were shown in Fig. 1. The various electrical circuits were traced in detail for practically all conditions of operation of the different combinations.

The actual locations of the different parts of a starting, lighting and ignition system similar to the one shown in Fig. 1 as they would appear on the car are shown in Fig. 2, which might be called a ghost view of the electrical equipment and circuits. The various electrical circuits traced in Fig. 1 easily may be traced in Fig. 2 by using exactly the same description as the same lettering has been used in both cases. Such a diagram should be of great value to the repair man in tracing the actual electrical circuits on the car, as he, by reference to this kind of a diagram, easily can identify each in-

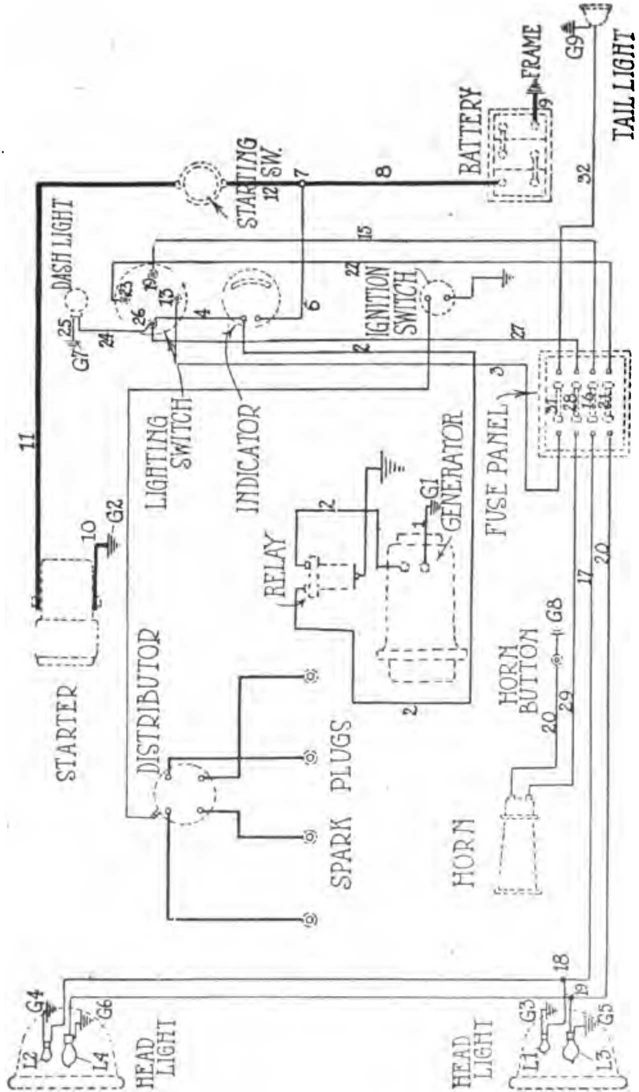


Fig. 3—**Wiring diagram of a typical three-unit, single-wire electrical system such as would be supplied by makers of such equipment. This is the wiring diagram of the system illustrated in Figs. 1 and 2**

dividual conductor, the circuit to which it belongs and the current it is supposed to carry under normal conditions. Diagrams of this kind will be given in connection with the leading makes of systems to be described later.

A type of wiring diagram usually supplied by the manufacturers of starting, lighting and ignition equipment is shown in Fig. 3. This is a diagram of the same system shown in Figs. 1 and 2, and the same lettering has been used in designating the different parts, wires and connections as was used in Figs. 1 and 2. It thus is seen that the wiring diagram itself merely gives the different electrical connections without reference to the relative location of the different parts and devices forming the various electrical circuits.

Analysis of Trouble

The various kinds of individual troubles which may occur on any particular system are so numerous that it would be impossible to expect the reader to wade through a detailed description of each and every one. A description of the more important ones and those that are most likely to occur will be given, and with these as a basis the reader may go on and study the more uncommon cases and perhaps more complicated cases.

You must have in mind that there are three things associated with every electrical circuit, namely, the resistance of the circuit which opposes the free movement of the electricity around the circuit, the electrical pressure, or electricity moving force which causes the electricity to move through the circuit, and the electric current which is a measure of the rate at which the electricity is moving just as the current in a river is a measure of the rate at which the water is moving down the river. The rate at which the electricity moves, or the current, in amperes is equal to the effective electrical pressure in volts acting in the circuit divided by the resistance of the circuit in ohms. Thus if a lamp circuit has a resistance of 2 ohms and the electrical pressure in this circuit is 6 volts, a current equal to 6 divided by 2, or 3 amperes, will be produced when the circuit is closed. The effective pressure as used means the difference in the sum of the pressure acting in one direction around the electrical circuit and the sum of the pressures acting in the opposite direction. Thus if a generator having a terminal pressure of 7.5 volts is charging a battery whose terminal pressure is 7 volts, an effective pressure of 7.5 minus 7 or .5 volts will be acting in the circuit.

In order that there be an electrical current in any circuit an effective pressure must be acting in the circuit and the circuit must be closed. So in any electrical circuit in which there is no current the difficulty is due to there being no electrical pressure in the circuit or the circuit is not closed. For example, if the ammeter indicates zero current when the headlights are turned on, see Figs. 2 and 3, you immediately know the difficulty. Either there is no electrical pressure or the circuit is open. If at the same time the cowl and taillights operate normally, you immediately know that the difficulty is not due to a lack of electrical pressure but to an open circuit. An inspection of the diagrams in Figs. 2 and 3 will show that all the various light circuits have certain wires and connections in common. That is, starting with the frame of the car, you can pass along wire 9, through the battery along wire 8 to the junction point 7, along wire 6 and through the ammeter along wire 4 to terminal 26 on the cowl switch, where the circuit branches to the horn, the cowl light and the tail and headlights through the cowl switch. If the cowl and taillights operate, all connections and wires along the circuit just traced are O. K. up to the terminal 26 on the cowl switch. If neither the low- nor high-candlepower bulbs will burn, the difficulty is more than likely in the switch, although both fuses 21 and 16 may be burnt out. The fuses may be tested by connecting the terminals with a pair of pliers or a short piece of wire, thus closing the circuit if the fuse is burnt out. The connections in the switch may be tested by connecting terminals 26 with terminals 23 and 19 respectively.

If neither of these tests locate the difficulty, the circuit is open at some other point or it may be open at both the fuses and switch, in which case neither of the tests would locate the trouble. A test lamp whose voltage corresponds to that of the headlights may be used as follows in locating the difficulty. Mount the lamp in a socket provided with flexible terminals several feet long and connect one of the free ends of the flexible wire to the frame of the car and the other to terminal 26 on the cowl switch. If the test lamp lights it is O. K. and the circuit is, of course, O. K. up to the terminal 26, as the cowl light burned. Turn the cowl switch so the high-candlepower light should burn and then connect the free terminal of the test lamp to the terminal 19, and if the test lamp burns the switch is O. K. If the lamp does not burn, the connection in the switch is at fault. If the switch is O. K., proceed to the right-hand terminal of fuse 21 and again test. If the test lamp burns, wire 22 is O. K. Then touch the left-hand terminal of fuse 21, and if the lamp burns the fuse is O. K. Next go to junction point 19, if it is possible to make electrical connections there; if not, open up headlights and test circuits by applying end of test circuit to terminals in lamp sockets. Proceed along the circuit in this manner until you reach a point on the circuit where the test lamp does not light. The circuit is open between this point and the last point where it did light. This same line of reasoning will apply to every electrical circuit on the car, and difficulties caused by open circuits easily may be located by following carefully the wiring diagram.

The importance of the wiring diagram in locating cases of trouble thus is readily seen, and you cannot become too familiar with these diagrams for the different systems.

If the system happens to be grounded at some point that is not supposed to be grounded you can test for such a ground as follows. First remove all grounds from the system as shown in the wiring diagram. This may be done by disconnecting the grounded terminals of the battery and the grounded terminal of the generator and removing all lamps. The ground connection for the horn circuit and starting motor circuit should not interfere with any test on these two circuits, which are open at the horn button and starting switch respectively. Now connect the terminal of the battery, which normally is grounded to the frame of the car by the test lamp circuit. If the wiring to which the other terminal of the battery is connected happens to be grounded, the lamp will light, provided the resistance of the ground connection is not too high. The different light circuits then may be tested by disconnecting them in turn from the battery by taking out the fuses or loosening the wires from under the screw terminals if no fuses are in the circuit.

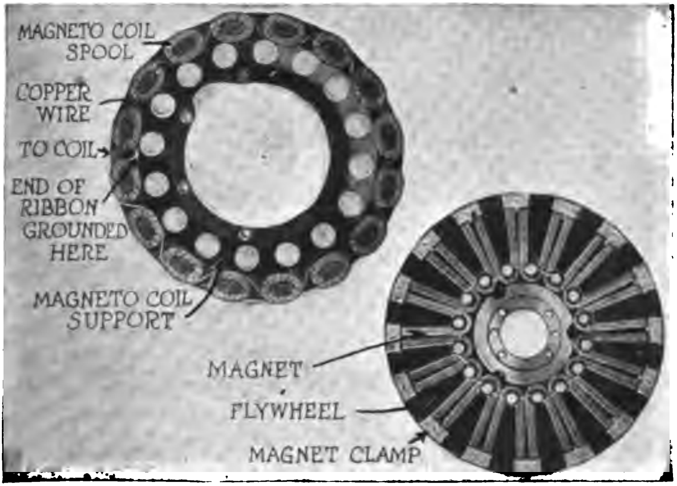
CHAPTER II

Stock Ford Ignition and Lighting System

THE ignition and lighting system used on the Ford car as standard equipment is decidedly different from any other system now in use and it is deserving of a thorough description on account of the many systems in service.

Electrical energy is obtained from a specially constructed magneto, which consists of sixteen coils of flat copper ribbon wound around sixteen equally spaced iron cores, which are mounted on a special structure bolted to the transmission case directly in front of the flywheel. Sixteen small permanent horseshoe magnets are mounted on the front face of the flywheel, and just enough clearance is allowed between the pole-pieces of these permanent magnets and the iron cores about which the copper coils are wound to prevent them from striking when the flywheel is caused to rotate. The coils and their mounting are shown in Fig. 4. The sixteen magnets and the method of mounting them are shown in Fig. 5. The magnets are so placed relative to each other that adjacent ends are of the same magnetic polarity, and these two ends are joined magnetically, so as to form a single magnetic pole, by a clamp of magnetic material. There are then sixteen magnetic poles around the outer edge of the flywheel, and these poles are alternately of north and south magnetic polarity.

When the magneto is assembled and the magnetic poles are directly opposite the iron core of the coils, there will be magnetic lines of force across the gap between the poles and the iron cores, and the direction of these lines of magnetic force will be from the north magnetic poles across the gap, through the iron core under the north poles, through the structure supporting the iron cores to the cores under the south poles of the magnets, up through these cores across the air gap to the south magnetic poles, thence through the magnets to the north magnetic poles, which completes the magnetic circuit or path of the lines of magnetic force. With the magnetic poles directly opposite the iron cores of the coils, there is a maximum number of lines of magnetic force through the coils, since the magnetic circuit with the various parts in this relation to each other offer a minimum opposition to the production of lines of force. The direction of the lines of force through eight of the coils will be from the north magnetic poles on the permanent magnets through the coils toward the support for the iron cores, and the direction of the lines of magnetic force through the remaining eight coils will be from the support for the iron cores toward the south magnetic poles on the permanent magnets. Now, if the magnetic poles be moved so that they are midway between the iron cores, there will be a minimum number of magnetic lines through the coils as this position of the magnets and the iron cores offers a maximum opposition to the production of lines of force. If the magnetic poles be moved farther on so that they are again opposite the iron cores, the magnetic lines through the coils will again have a maximum value. The direction of the mag-



Figs. 4 and 5—Stationary coils of Ford magneto mounted on metal coil support, left, and permanent horseshoe magnets mounted on front face of flywheel netic lines through the coils in this last position will be in just the reverse direction to what it was in the first position, since the north magnetic poles are now opposite iron cores, which originally had south magnetic poles opposite them, and south magnetic poles are now opposite iron cores which originally had north magnetic poles opposite them.

If the magnetic poles be advanced another sixteenth of a revolution, the polarity of the magnetic poles and iron cores will be

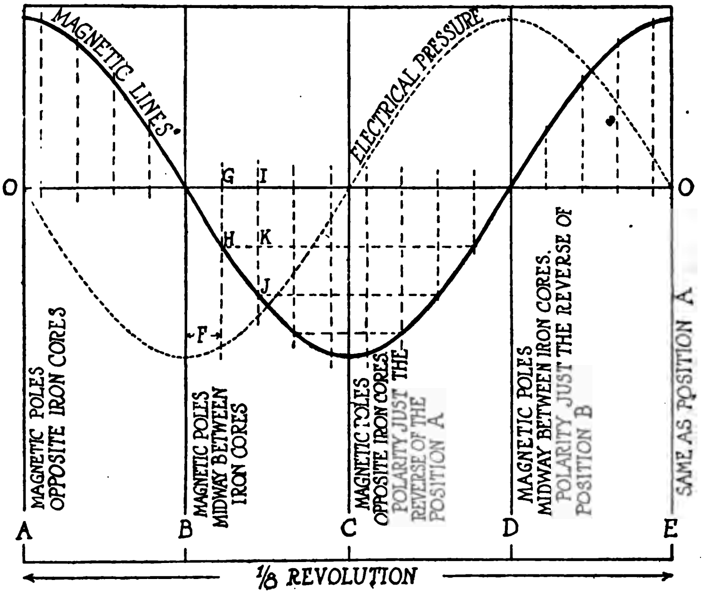


Fig. 6—Variation in magnetic lines through coils for different positions of magnetic poles with reference to iron cores on which coils are wound

the same as at the beginning. Hence, the magnetic lines through any particular coil pass from a maximum value in one direction through the coil to zero value, build up to an equal maximum value in the opposite direction through the coil, then to zero value and increase to a maximum value in the same direction as it originally had, while the magnetic poles are moving from a position directly opposite the iron cores through an eighth of a revolution. The variation in the value of the number of magnetic lines through the coils for different positions for an eighth of a revolution is shown in Fig. 6. The distance of the heavy curve marked magnetic lines above or below the horizontal line 00 is a representative of the value of the number of magnetic lines through the coils for the different positions. Thus for position marked A the magnetic poles are opposite the iron cores and the value of the magnetic lines is a maximum. For position B the magnetic poles are midway between the iron cores, and the value of the magnetic lines through the coils is zero. For position C the magnetic poles are again opposite the iron cores, but the polarity of the magnetic poles in relation to the iron cores is just the reverse of what it was for position H, and, hence, the value of the magnetic lines through the coils will have a maximum value for position A. The magnetic lines through the coils are zero in value for position D and again reach their original maximum value for position E.

As a result of the magnetic lines of force through the cores changing in value an electrical pressure will be generated in the different coils, and the direction of the generated pressure in adjacent coils will be in the opposite direction around the coils, since the magnetic lines pass through adjacent coils in opposite directions. The coils, however, are so connected that the electrical pressures all act in the same direction and the total electrical pressure between the terminals of the magnetos at any instant is equal to the sum of the electrical pressures in the sixteen coils. The value of the electrical pressure in each coil at any instant will depend upon the number of turns in the coil and the rapidity with which the magnetic lines through the coil are changing. An inspection of the curve in Fig. 6, which shows the variation in the magnetic lines through the coils for different positions, will show that the electrical pressure is zero when the magnetic lines are a maximum and that the electrical pressure is at a maximum when the magnetic lines through the coils are equal to zero, etc. These results can be explained as follows: Suppose we take a small part of a revolution, such as 1/144th, as shown at F in the figure. For this small part of a revolution, the magnetic lines increase in value from zero to GH. For the next 1/144th, of a revolution they increase in value from GH to IJ, or the net increase is KJ. It is thus seen that the net increase in magnetic lines is growing less for each 1/144th of a revolution, until the magnetic lines through the coils have reached their maximum value when the net increase is zero.

As the magnetic lines through the coils decrease in value, the rapidity with which they are changing in number increases until the lines through the coils are equal to zero, when the rapidity of their change in number reaches its maximum value and then starts to decrease and again becomes zero when the lines through the coils have reached their maximum value. As a result of this varying rapidity with which the lines through the coils are changing, a varying electrical pressure will be produced in the coils. The induced electrical pressure may be represented by a curve having the form of the dotted curve, in Fig. 6. The electrical pressure produced in the coils while the magnetic lines are decreasing in value in one direction through the coils will be in the same direction as the electrical pressure produced in the coils while the magnetic lines are increasing in value through the coils in the opposite direction.

Such a pressure as the one shown in Fig. 6 is called an alternating pressure, because it is first in one direction and then in the other. All values of electrical pressure, represented above the horizontal line 00, are considered positive and all values below the line are considered negative. A complete system of positive or negative values is called an alternation, and the complete alternation constitutes what is called a cycle. In the Ford magneto there are sixteen alternations per revolution and eight cycles per revolution. If this alternating pressure is connected in a closed electrical circuit, it will produce an alternating current in the circuit and the current will complete the same number of cycles in a given time as the electrial pressure completes. The number of cycles the electrical pressure and current complete in a second is called the frequency of the pressure and current. The frequency of the electrical pressure developed by the Ford magneto will be equal to eight times the number of revolutions of the flywheel in a second.

Magneto Terminal Connections

One terminal of the circuit formed by connecting all the sixteen coils in series is grounded permanently by connecting it to the metal support for the iron cores, which in turn is bolted to

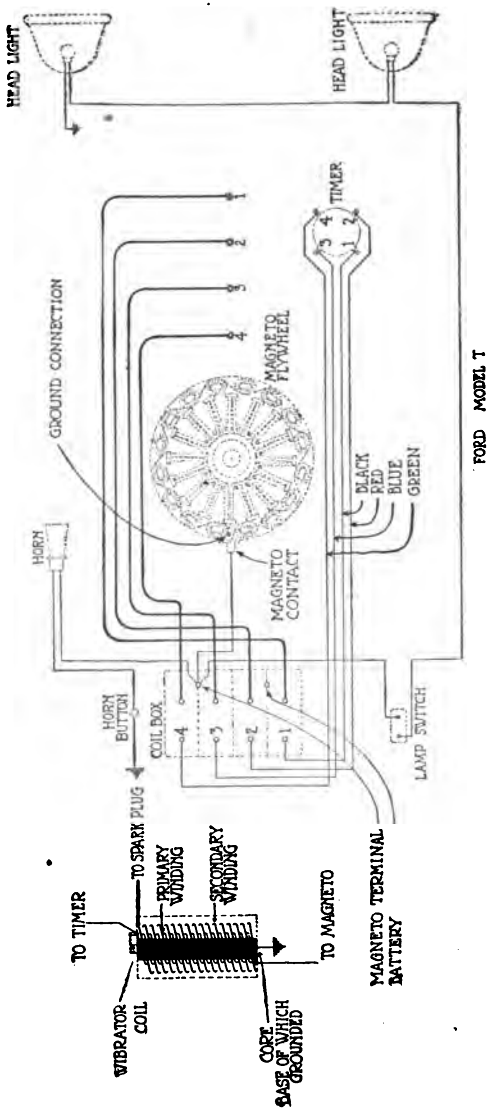


Fig. 7—Wiring diagram of standard equipment on a Ford

the transmission case. The remaining terminal is connected to an insulated binding post mounted on top of the transmission

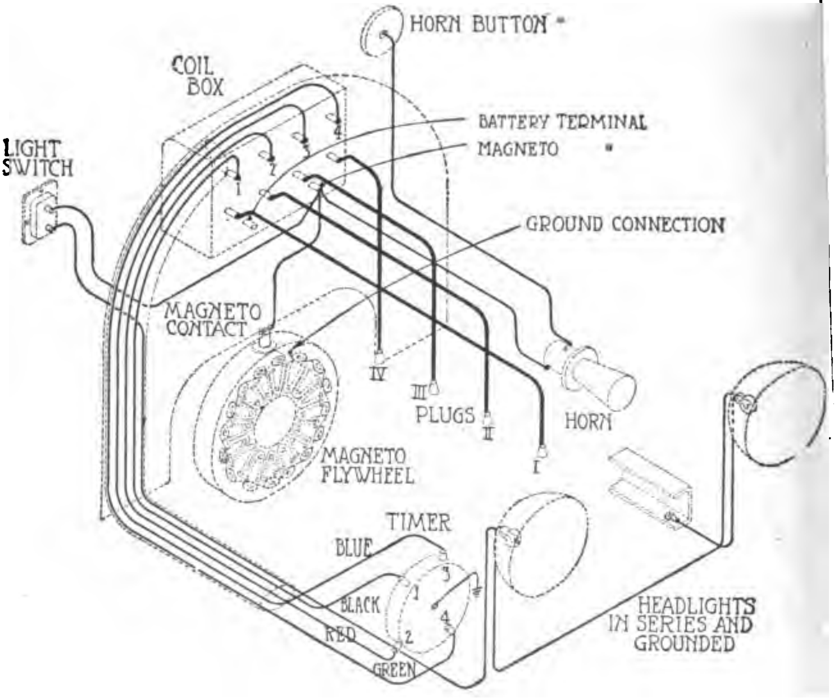


Fig. 8—*Perspective view of wiring and component parts of Ford standard electrical equipment*

case. The terminals of the magneto, then, are the insulated binding post and the ground connection.

Ignition System

The ignition for the Ford car is taken care of by a four-unit induction coil mounted on the dash and so arranged that energy may be supplied to its primary winding from either of two sources, depending upon the position of the ignition switch. The only source of electrical energy provided by the manufacturers of the car is the magneto, but a battery connection is provided in the coil box and may be used merely by grounding one terminal of the battery and connecting the other terminal to the binding post on the coil box.

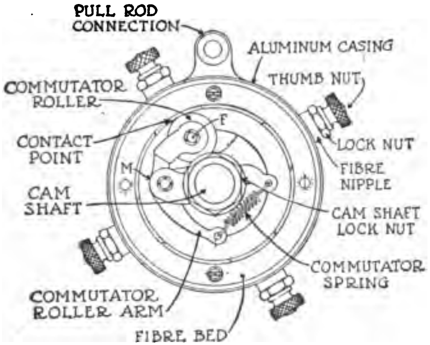


Fig. 9—Interior of Ford timer

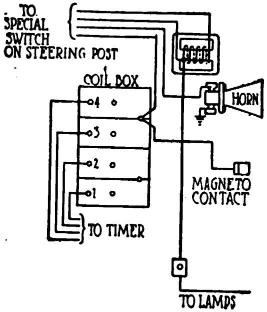


Fig. 10—Connections of special dimmer and leads to special switch on steering post

A wiring diagram of the lighting and ignition system supplied as standard equipment on the Ford car is shown in Fig. 7, and the relative location of all the different parts, together with their various electrical connections, is shown in Fig. 8. The four primary ignition circuits may be traced as follows: Starting with the magneto contact, along the insulated wire to the magneto terminal on the coil box, then to the magneto contact on the switch on the front of the coil box, and when this switch is closed on the magneto, all the primary windings are connected to the magneto contact but the circuits through these various windings are closed one at a time and in a definite order by the commutator, or timer, which grounds the different wires as the roller contact in the timer makes contact with the terminals to which the different wires are connected. The interior construction of the timer is shown in Fig. 9. When a battery has one terminal grounded and the other terminal connected to the battery terminal on the coil box and the switch on the front of the coil is thrown in the position marked battery, the battery replaces the magneto as a source of electrical energy and all the other operations remain the same.

A vibrator is connected in series with each of the primary windings, and when any one of the primary wires leading to the timer is grounded the vibrator in that particular primary circuit will vibrate as long as the circuit is closed, which will cause a high voltage to be induced in the secondary windings surrounding the primary winding of the induction coil. One terminal of each of the four secondary windings is grounded, and the remaining four terminals are connected to the four spark plugs by suitable lengths of high-tension wire, as shown in Figs. 7 and 8. The primary wires leading from the induction coil to the timer are marked with colored threads as shown in Figs. 7 and 8.

Lighting Circuit

The lighting circuit for the headlights may be traced as follows: From the magneto contact to the magneto terminal on the coil box, then to the lamp switch on the dash, through the switch when it is closed, then to the right-hand headlight and through the bulb, then to the left-hand headlight and through the bulb, then to ground and through the winding of the magneto to the magneto contact which completes the circuit. The two headlight bulbs are in series and if they are alike, approximately half of the electrical pressure generated in the winding of the magneto will act on each of the lamps, the remainder being used in overcoming the resistance of the winding of the magneto, the resistance of the connecting wires, ground connections, switch contact resistance, etc.

Horn Circuit

The horn circuit may be traced from the magneto contact to the magneto terminal on the coil box, then to the horn, through the horn to the horn button mounted on the steering post, through the horn button when it is closed to ground, through the winding of the magneto to the magneto contact which completes the circuit.

Combination Switch and Dimmers

The Ford company is equipping its cars now with a combination horn and light switch, which is mounted on the steering column and has very much the same general appearance as the horn button except the switch is longer to provide the necessary space for the various additional contacts and terminals. In addition to the combination horn and light switch, the Ford company is providing a means of dimming of the headlights. The dimmer consists of a coil of wire wound about a laminated iron core and so arranged that it may be connected in series with the headlights by a special switch on the steering post.

The special switch is so constructed that a small pressure on its rounded top closes the horn circuit and a small rotation from its normal position connects the lamps to the magneto with the dimmer coil in circuit and a further slight rotation connects the lamps directly to the magneto. The electrical connections of this special switch are shown diagrammatically in Fig. 10. Pressing the switch connects wires A and B, rotating the switch to the second position connects wires A and D and rotating it to the third position connects wires A and C. The light circuit is entirely open with the switch in the first position. When the switch is in the second position and the wires A and D are connected, the winding on the dimmer is connected in series with the lamps. The action of this coil is dependent upon a combination of the resistance of the coil and a property of the coil called its inductance. The effect of the inductance of the coil depends upon the frequency of the current in its windings, and this effect increases with an increase in frequency and decreases with the decrease in frequency.

If the engine speeds up there is an increase in the frequency of the generated electrical pressure, and also an increase in the value of the electrical pressure, but the increase in electrical pressure is offset to a certain extent by the increase in the effect of the inductance due to the increase in frequency and the current through the lamp will remain nearer constant in value than it would if a resistance alone were used.

Ignition Trouble

The uneven sputter and bang of the exhaust means that one or more cylinders are exploding irregularly or not at all and that the trouble should be treated promptly and overcome. Misfiring, if allowed to continue, will in time injure the engine and the entire mechanism. If you would be known as a good driver, you will be satisfied only with a soft steady purr from the exhaust, and if anything goes wrong, stop and fix it if possible rather than wait until you get home.

A missing cylinder can be detected by manipulating the vibrator on the spark coils. Open the throttle until the engine is running at a good speed and then hold down the two outside vibrators, Nos. 1 and 4, with the fingers, so they cannot buzz. This cuts out the two corresponding cylinders, No. 1 and 4, leaving only Nos. 2 and 3 running. If the two cylinders, Nos. 2 and 3 explode regularly, it is obvious that the trouble is in either cylinder No. 1 or No. 4, or both. Now relieve No. 4 vibrator and hold down No. 2 vibrator and No. 3 vibrator and also No. 1 vibrator. If No. 4 cylinder explodes evenly, it is evident the trouble is in some other cylinder. In this manner all the cylinders in turn may be tested until the trouble is located. Examine the spark plug and vibrator of the cylinder in trouble.

The gap in the spark plug should be approximately $\frac{1}{32}$ inch in length and the plug should be free from an undue accumulation of grease and carbon. If the points in the vibrator are pitted, they should be filed flat with a fine double-faced file and the adjusting thumb nut turned down so that with the spring held down, the gap between the points will be a trifle less than $\frac{1}{32}$ inch. Then set the lock nut so that the adjustment cannot be disturbed. Do not bend or hammer the vibrators, as this would effect the operation of the cushion spring on the vibrator bridge and reduce the efficiency of the unit.

If with the vibrator properly adjusted and the plug cleaned and adjusted the cylinder still fails to operate, then examine the wiring and connections carefully for loose connections and open circuits. The coil itself may be tested by changing it and some other coil which is operating correctly. If the cylinder still fails to operate properly after making the above tests, the trouble is probably due to an improperly seated valve, worn timer or short-circuit in the timer wiring. The valves in each cylinder may be tested by lifting the starting crank slowly the length of each cylinder in turn, a strong or weak compression in any particular cylinder easily being detected. It sometimes happens that the packing between the cylinder head and the cylinder becomes leaky, thus permitting the gas under compression to escape, a condition that can be detected by running a little lubricating oil around the edge of the packing and noticing whether bubbles appear or not.

The surface of the circle in the timer around which the roller travels should be clean and smooth, so that the roller makes a perfect contact at all points. Should the roller fail to make a good contact on any one of the four contact points, its correcponding cylinder will not fire. The surfaces should be cleaned with gasoline. In case the fiber, contact points and roller of the timer are badly worn the most satisfactory remedy is to replace them with new parts. The spring in the timer should be strong enough to make a firm contact between the roller and the four contact points, as the roller is made to rotate by the gearing connecting it to the engine. Carefully inspect the four wires leading from the primary terminals of the coil box to the four binding posts on the timer to see that they are not shorted or broken and that the ends at the timer are not in contact with the case, thus causing a more or less perfect ground connection.

Oil Troubles

In very cold weather the very best grades of oil are likely to congeal to some extent, and if this happens the roller may be prevented from making perfect contact with the contact points embedded in the fiber. To overcome the possibilities of an occurrence of this kind and also to prevent the contact points from rusting, a mixture of 25 per cent kerosene with the commutator lubricating oil is recommended, which will thin it sufficiently to prevent congealing or freezing, as it is commonly called.

CHAPTER III

Special Systems for Ford—Gray & Davis

QUITE a few of the leading manufacturers of starting and lighting equipment for the larger car also make a special line of equipment which easily may be installed on the Ford car. These various special systems are, as a whole, simple and compact, and everything necessary to install them properly on the car is provided by the manufacturers of the equipment, and all that is necessary is a very limited knowledge of the car and the few necessary tools supplied as a part of the car equipment. The selection of an electrical system, especially when it is to be installed by the car owner or the local garage man whose knowledge of electrical systems is, as a rule, quite limited, is in a great measure influenced by the ease with which the system may be installed. In practically every case this necessitates the removal of the radiator, the radiator brace rod, hose connections to the radiator, ventilating fan, fan belt and fan pulleys, cylinder head and, in some cases, the timing gears. In removing the timing gears it is, of course, necessary to remove the timer, but before doing any dismantling both the carbureter and timer should be adjusted for efficient running, and should the engine be turned over while the timing gears are off, the timing must be readjusted when the engine is being assembled. The removal of all these parts and the adjustments mentioned are described fully in the Ford manual or instruction book, and also on account of the garage men being so familiar with the construction of the Ford car it is not deemed necessary to repeat these instructions.

A very important precaution which should be observed before starting to tear down the car is to check over the list of parts sent with the outfit and those actually received. The reason for this precaution is obvious, as occasionally quite an essential part may have been omitted, and if this is not discovered until the process of installing the equipment has been completed partially the work must be done all over again or the car allowed to stand until the missing part or parts are obtained.

Gray & Davis for Ford

The two Gray & Davis systems for the Ford car are of the two-unit, 6-volt single-wire types. The generator of one system has electromagnetic regulation and the generator in the other system has third-brush regulation.

The order of procedure to be followed in tearing down and preparing the engine is shown in Figs. 11 and 12. Drain the radiator by opening the drain cock shown at I in Fig. 11. Remove the headlights and headlight supports shown at 3 in Fig. 11. Loosen upper hose clamp on lower water connection, shown at 4 in Fig. 11. Loosen the lower hose clamp on top the water connection, shown at 5 in Fig. 11. Remove the two radiator retaining nuts shown at 6 in Fig. 11. Remove the radiator dash tie rod shown at 7 in Fig. 11. The radiator is now free and can be removed. Next remove fan bracket and fan as shown at 1 in Fig. 12. Crank the engine until the pin in fan pulley is straight up

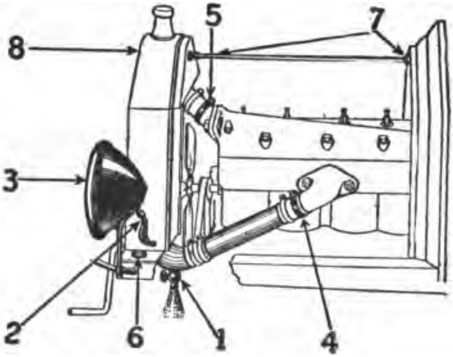


Fig. 11—Parts of Ford car to be removed in mounting Gray & Davis starting and lighting system

and down, 2 in Fig. 12. Drive out the pin in the jaw clutch, shown at 3 in Fig. 12. Remove the starting crank, 4, and fan belt 5. Remove the cotter pin and pin from fan pulley and then remove the pulley, 6, in Fig. 12. Remove the second, third, fourth and fifth bolts from the crankcase flange, shown by 7 in Fig. 12. Remove the front bolt 8 from the side water connection. Remove the left-hand bolt 9 from the top water connection. Remove the second cylinder head bolt 10.

Place the silent chain at the rear of the engine support and around the engine crankshaft, as shown at 1 in Fig. 13. Place the Ford starting crank jaw clutch inside of the crankshaft on the crankshaft as shown at 3 in Fig. 13. Slip the new fan belt in place. Fasten the sprocket to the crankshaft with the pin provided for that purpose, as shown at 5 in Fig. 13. Replace the starting crank 6 and fasten the jaw clutch to the end of the starting crank with the pin 7, as shown in Fig. 13.

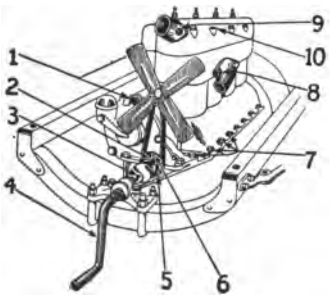


Fig. 12—*Ford engine in process of preparation for mounting Gray & Davis system*

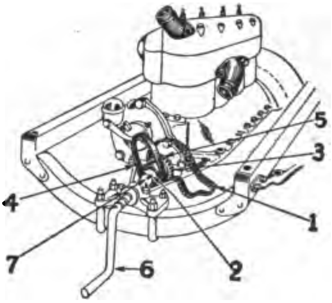


Fig. 13—*Installing crankshaft sprocket, silent chain and fan belt in mounting Gray & Davis*

The generator and starting motor units are shown attached to their mounting bracket in Fig. 14 and before attempting to install the combination on the engine the following inspection should be made carefully. See that the motor terminal marked 1 is free from contact with any other metal and that the generator terminal marked 2 is not damaged and is insulated properly. See that the various rotating parts marked 3 in the figure turn freely. Carefully clean off any dirt or dust from around the oil cups marked 4 and place a small quantity of oil in each of them. Release the top adjusting screw, marked 5, a small amount. Loosen the two lower clamp nuts marked 6, and also the two upper clamp nuts at the rear, marked 7. Slightly loosen the one middle clamp lock nut, marked 8.

The adjustment in the chain is taken care of by moving the generator and starting motor up and down on their mounting bracket until there is the proper tension in the chain and then clamping the two units securely in place. Inasmuch as the chain will stretch in service and this will necessitate the generator and motor being moved up on the bracket to take up the slack, it is essential that they be placed in the lowest possible position on the bracket before being attached to the car.

Place three spacers $\frac{3}{8}$ inch long over the first, second and third holes in the crankcase flange, as shown at 1 in Fig. 15, and then place the mounting bracket 2 in position. Pass the $\frac{3}{8}$ by $2\frac{1}{8}$ inch bolts through the holes in the lower end of the mounting bracket but do not put on the nuts. Tilt the mounting bracket forward and slide the driving chain 12 into position on sprockets. Attach the bracket with a cylinder head bolt as shown at 5 in the figure but do not tighten the nut. Place the $\frac{11}{32}$ inch spacer between the mounting bracket and top water connection and bolt loosely in place with a $\frac{7}{16}$ by $2\frac{5}{8}$ inch bolt as shown at 6. Place a $\frac{11}{32}$ inch spacer between the bracket and the side water connection

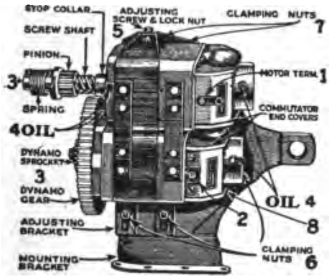


Fig. 14—*Generator and starting motor attached to the mounting bracket*

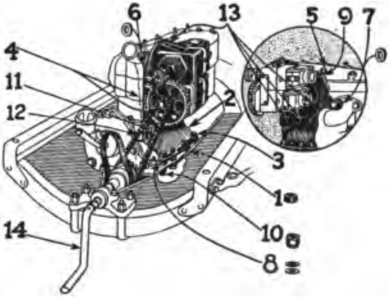


Fig. 15—*Gray & Davis starting and lighting units mounted on Ford* and bolt it loosely in place with a $\frac{7}{16}$ by $2\frac{5}{8}$-inch bolt, as shown at 7. Place ½-inch spacer under the bracket so that the chain will be tight when the units are in their lowest position on the mounting bracket, as shown at 8. Shim up the space between the bracket and cylinder head with washers as shown at 9 in upper right-hand part of Fig. 15. Fasten the three lower bracket bolts with lockwashers and nuts and finally the water connection bolts 6 and 7 and cylinder head bolt 5. Fasten the bracket stay-bolt 11. Adjust the chain 12 to a moderate tension and lock the units in place by tightening all bracket clamp nuts, 13. Then crank the engine and see that it does not bind.

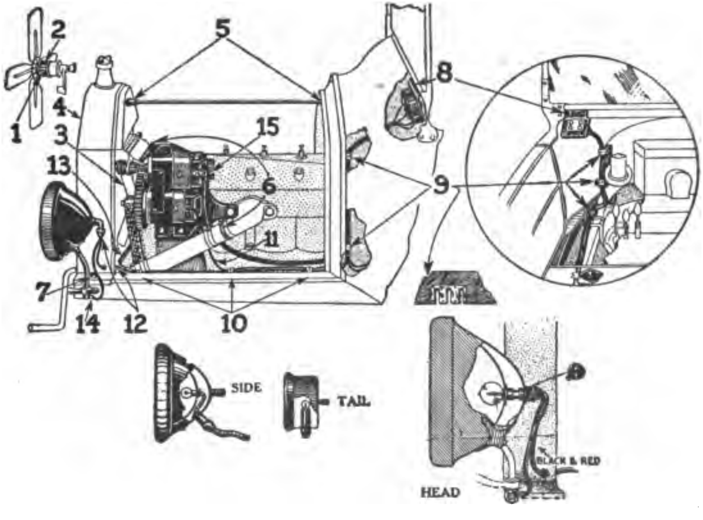


Fig. 16—Installing Gray & Davis wiring and lighting switch

Attach the split pulley to the fan hub and fasten it in place with the four screws as shown at 1 and 2 in Fig. 16. Slip the belt in place and attach the fan, as shown at 3. Replace the radiators 4, replace the radiator tie rod 5, replace the hose connections 6 and bolt the radiator in place by the bolts at 7. Attach the lighting switch 8 to the cowl board with some $\frac{3}{16}$-inch screws.

Cut corner off of the toe board and attach the green lighting cable clips to the dash with ½-inch wood screws, as shown at 9 in Fig. 16. Fasten the three wire clips to the left-hand side of the frame as shown at 10. Fasten the green wire to dynamo terminal as at 11. If the generator has electromagnetic regulation the green wire is attached to the terminal on the regulator mounted on top of the motor. Then connect the short black and red wire to the left-hand headlight, as shown at 12. Pass the long black and red wire through the radiator tube 13 to the right-hand headlight. Ground the short wire from each headlight to the car frame as shown at 14. Connect the starting cable 15 to the terminal on the starting motor. This cable is marked by a copper terminal at each end. Refill the radiator and watch carefully for leaks in the circulation system. In connecting the black and red wires to the terminals of the lamp connection you should follow the diagram given in the upper right-hand corner of Fig. 16.

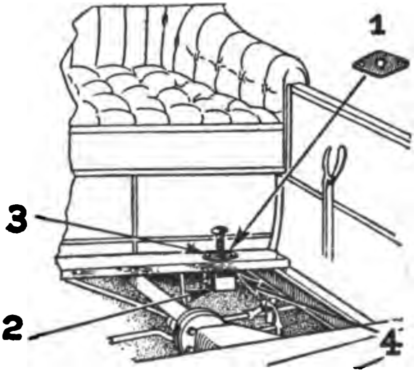


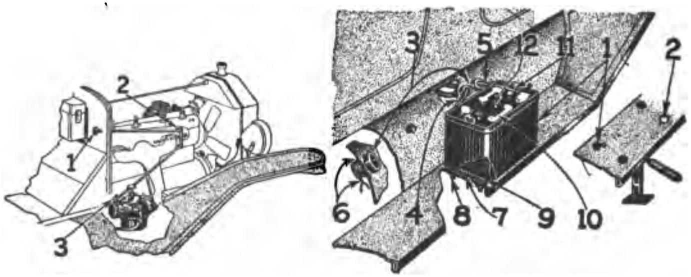
Fig. 17—Method of installing Gray & Davis starting switch on Ford car

The location of the starting switch and the method of installing it are shown in Fig. 17. Take the plate 1 off the starting switch and use it to mark the holes in the heel board, 2 inches in front of the rear edge of the heel board and 9 inches from the sill, as shown in the illustration. Drill three holes for the starting switch in the heel board and attach the switch with one bolt at the side toward the center of the car as shown at 3. Then attach the other switch bolt, with the cable supporting clamp holding the two wires, and secure the spring and knob with its pin.

At a point on the dash 2 inches to the right of the coil box and 6 inches above the edge of the toe board, drill a $\frac{7}{32}$-inch hole, as at 1 in Fig. 18. Pass the upper rod through this hole and connect the lever arm 2 vertically to the forward exhaust manifold stud. Connect the lower rod 3 to the priming lever on the carbureter. Work the rods back and forth several times to make sure they return to normal position when released.

Installation of Battery

Place the battery box on the right-hand running board and mark four holes with a center punch as shown at 1 in Fig. 19. The position of the battery box should be such as to permit easy opening of the car doors and ready access to the box itself. Drill four $\frac{11}{32}$-inch holes through the running board 2, using a jack or prop to support the running board while drilling. Replace the battery box on running board to mark the holes in the splash plate for insulating cable bushings 3, then drill two holes $1\frac{3}{8}$ inch in diameter. Insert the insulating cable bushing 4 in left-hand hole and secure it in place with wooden nut; do the same with the right-hand bushing 5. The wooden nuts may be secured



Figs. 18 *and* 19, *left to right—Fig.* 18, *Gray & Davis priming rod connections on Ford; Fig.* 19, *installing battery for Gray & Davis on Ford*

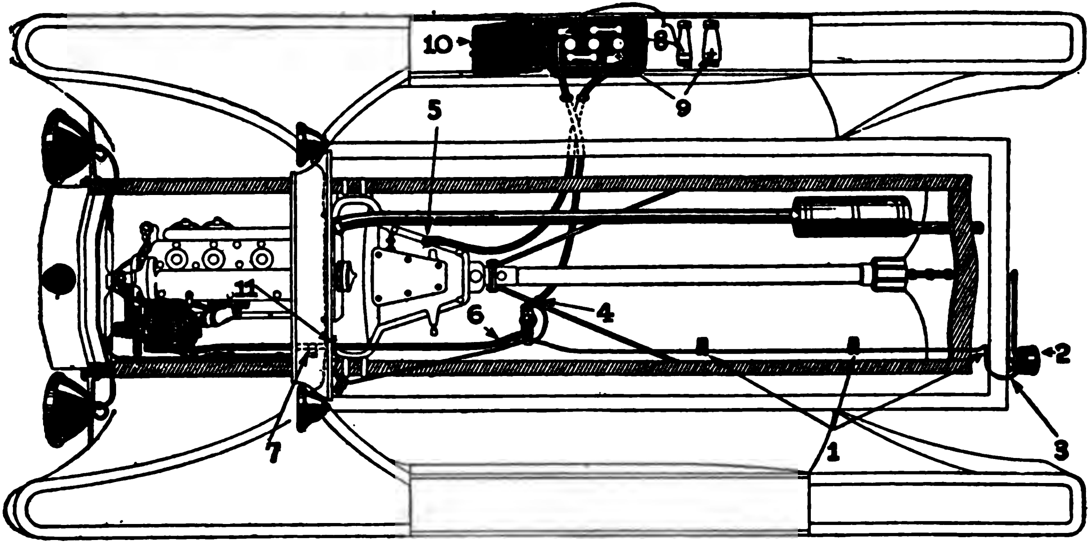


Fig. 20—*Plan view of complete Gray & Davis installation on the Ford car* in position by twisting a piece of wire around the thread as shown at 6. A coat of heavy paint also will serve to hold the nut in place and at the same time preserve the insulator. Place the two wooden cleats 7 with holes in each end between the battery box and the running board. Bolt the battery box to the running board with ⅜-inch by 1½-inch bolts through the bottom of the battery box, cleats and running board, and secure the four bolts with nut and lock washers. Place the two special battery cleats 9 inside the battery box, one at each end, for the battery to rest upon so that the holes in the cleats will fit over the bolt heads in the bottom of the box. Slide the battery in place with the negative terminal of the battery toward the front of the car and put ¼-inch wooden strips, 10, at each side between the battery and the box. Attach the two holddown springs 11 so as to hold the battery securely in place. Examine the battery and if the solution does not cover the plates at least ¼ inch, add pure water, filling the cells to ⅝ inch above the tops of the plates.

Connecting the Wiring

The entire system in place is shown in Fig. 20 and the wiring in plan and perspective is shown in plan and perspective in Figs. 21 and 22, respectively. Attach the three clips holding the tail-lamp wire as shown at 1 in Fig. 20. Place the tail lamp in position as shown at 2, and connect the taillight wire 3 to the tail lamp. Tail lamps usually are made with a single-wire connector, and in such cases the metal body of the lamp must be connected metallically with the frame of the car. Be sure that the connecting surfaces are clean, free from paint and securely fastened. If the lamp is provided with a two-wire connector, another wire should be run from the second terminal of the connector to the metal framework of the car. Connect the short battery cable and the green and red wire to the starting switch terminal on the side nearest the center of the car, as shown at 4. Then pass the end of the cable through the forward insulator in the splash plate. This is the negative cable. Connect the long battery cable to the second gearbox bolt and secure it with a plain lock washer as shown at 5 in the figure, and pass the end of the cable through the rear insulator in the splash plate. Make as good an electrical connection to the gearbox as possible. This is the positive cable. Connect the starting motor cable 6 to the outside terminal of the starting switch. Support the starting motor cable by a clip 7 to the inside curved edge of the dash. Pass the negative battery cable through the battery box insulator and connect it to the negative battery terminal, 8.

The battery terminals are made of lead and should be handled carefully. In connecting the cables to the battery terminals, be sure that the terminals are cleaned thoroughly and fastened securely, as a good firm contact must be made to offer as low a resistance as possible. The positive battery cable terminal is a little larger than the negative one, and they correspond in size to the holes in the lugs forming the terminals of the battery. The positive battery cable terminal should not be connected to the battery or the fuses inserted until tests show that the wires are not in contact with the frame of the car or in contact with each other, thus causing a ground or short-circuit. Turn the lighting switch off and touch the positive battery cable terminal to the positive terminal of the battery. If there is a spark, it indicates a short-circuit or a ground. This trouble always should be corrected before

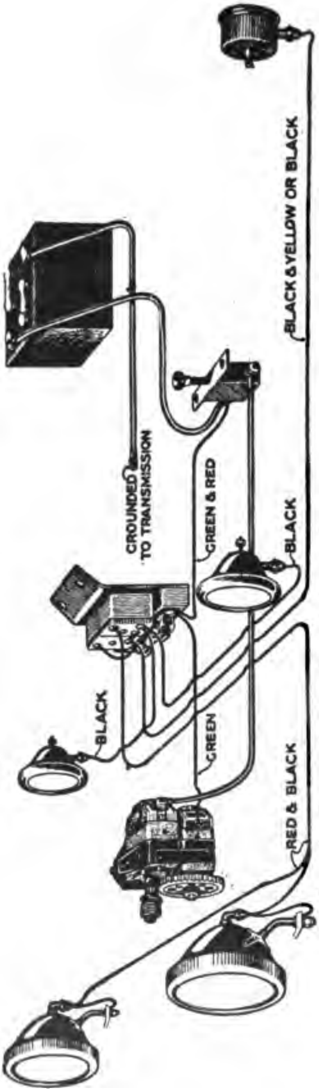


Fig. 21—Perspective of Gray & Davis electric system installed on a Ford

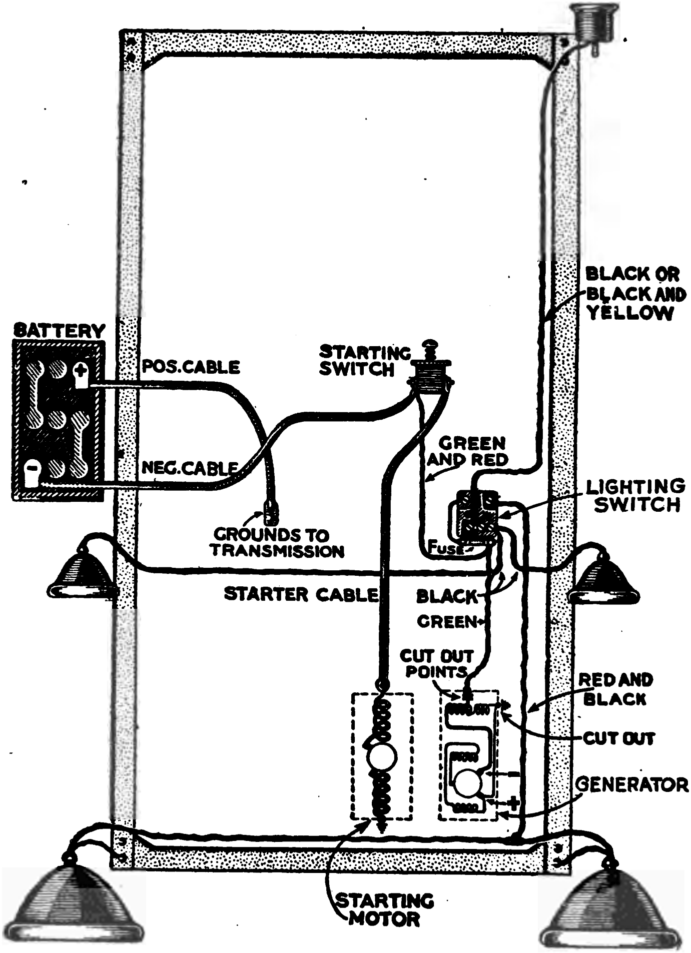


Fig. 22—Wiring diagram of Gray & Davis starting and lighting system for Ford car, third-brush regulation

making the final connection to the battery. Of course, if there is no spark when the test is made, the connections to the battery may be made permanent. After connecting the battery terminals secure the cover 10 on the battery box, and place fuse 11 in fuse clips of lighting switch.

Operating Instructions

The two generator bearings and the two motor bearings should be oiled every 200 miles, and care should be taken to keep the oil-well covers closed.

The chain should not be allowed to run slack. When the system is first installed, or when a new chain has been put on, the chain should be adjusted occasionally during the first few hundred miles of travel until all stretch has been taken out of it. The chain stretch will be quite slight after being run perhaps 500 miles. After long service, when all chain adjustment has been taken up, the chain may be shortened by taking out a pair of links. The latest type of chain is supplied with a removable pair of links, retained in position by two removable pins, which are identified easily, as these pins are a trifle longer than the regular riveted pins.

The wires are more or less subject to dislodgment and injury, and they should be examined occasionally to see that they are not resting on sharp edges of metal and that the insulation is not worn or injured. Examine the cables leading through the splash plate and battery box; the bushings must be intact and in place to protect the cable. If the insulation on any wire or cable is found to be injured, wrap the spot with insulating tape and make the necessary changes in the positions of the conductor or its supports to prevent a re-occurrence of the damage.

The engine never should be run with the battery disconnected or off the car without first insulating or removing two of the generator brushes from contact with the commutator, to prevent the generator from generating any electrical pressure in its armature.

Examine the brushes occasionally to determine whether they are excessively worn. The stop on the brush holder limits the downward travel. The brushes wear for a long time, but do not allow them to wear until they reach the limit, as poor brush contact on the commutator and burning of the commutator results. It is important when renewing brushes that each brush is connected firmly and is fitted properly to the shape of the commutator. The brushes should be in firm contact with the commutator and when raised by hand should return to their proper position freely. The brush tension, or pressure, on the commutator should be only moderate. The commutator, if coated or dirty, can be cleaned by holding a clean cloth slightly moistened with oil against the commutator while it is rotating. The commutator should be smooth. If roughened, it probably is due to burning where brushes are in contact, because of insufficient contact or pressure at the end of brushes. Examine brush tension, brush contact and swinging of brush holder. The commutator surface may be smoothed off by holding a very fine piece of sandpaper folded flat against the commutator by a square ended piece of pine wood. Never use emery cloth or emery paper. If sandpaper is held by hand it does not true up the surface of the commutator nearly so well as when pressed against the commutator by the piece of wood. The sandpaper should be 00 or finer. After using the sandpaper, wipe off the surface thoroughly, also brushes and brush holders, and if compressed air is available blow out interior of machine so as to remove any loose foreign matter, such as dust, which may have accumulated. Wipe off the commutator with a cloth which has a little clean vaseline on it before closing up the machine.

The threaded shaft on the end of the motor which carries the small driving pinion should be cleaned occasionally to prevent its sticking to the shaft on account of the oil gumming. The threaded portion should be cleaned with kerosene.

The following lamps are recommended by Gray & Davis: Headlamps 6-8 volt 15-candlepower, 2 inches round with helical filament and bayonet base, sometimes called ediswan base. If the base has a center contact, specify "single contact" but if it has two contacts specify "two contact." Side lamps 6-8 volts, 4 candlepower, bayonet base. Tail lamp 6-8 volts, 2 candlepower, bayonet base.

Lamps should be in focus for best results. Move bulbs in headlights forward or backward by turning adjusting screw in back of lamp housing until the most intense beam of light is obtained. Lamp brackets should be bent to direct rays downward on the road for best road illumination.

The ammeter, if it is to be installed permanently, may be mounted on the cowl to the right of the lighting switch. Be very careful to see that the ammeter terminals, nuts or washers do not come in contact with any other metal. Disconnect green and red wire from fuse block, and securely fasten it to right-hand terminal of ammeter, when facing toward the front of the car. From the left-hand terminal of the ammeter connect a short piece of wire to the fuse block terminal from which you removed the green and red wire. Now turn headlights on with engine at rest. Ammeter should indicate discharge. Should it indicate charge instead of discharge, the ammeter connections should be reversed.

The connections for a portable ammeter are the same as those for the one being installed permanently, and unless it is of the zero-center type the connections will have to be reversed when changing from a discharging to a charging condition of the battery or vice versa.

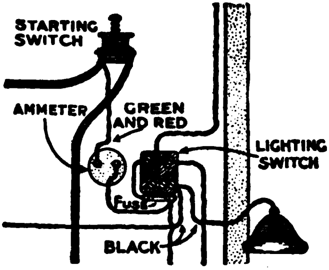


Fig. 23—Diagram showing method of connecting ammeter in circuit on Gray & Davis system for Ford car

A diagram showing the method of making the above connections is shown in Fig. 23.

Two Types of Generators

Two types of generators are supplied by Gray & Davis. Their chief difference lies in the method of regulating the output. In one type the regulation is by the third-brush method and in the other type the regulation is by electromagnetic means. Both these types of regulation have been described thoroughly in previous articles.

The operation of the two generators may be described briefly as follows: In the case of electromagnetic regulation there is an electromagnet controlling a set of contacts connected across the terminals of a resistance in series with the shunt-field winding of the generator, and this resistance is shorted or not shorted, depending upon whether the contacts are closed or open. The winding of the electromagnet is connected across the terminals of the generator and the contacts open when the voltage has increased to such a value that it will produce a current in the winding of sufficient magnitude to draw up the armature of the electromagnet. When the voltage drops below a predetermined value, depending upon the adjustment of the spring controlling the armature of the electromagnet, the armature will be drawn away by the spring as it overcomes the magnetic pull, and the contacts will be closed, thus causing the field current to increase in value and hence there will be an increase in voltage. This operation of the armature of the electromagnet takes place at a very rapid rate.

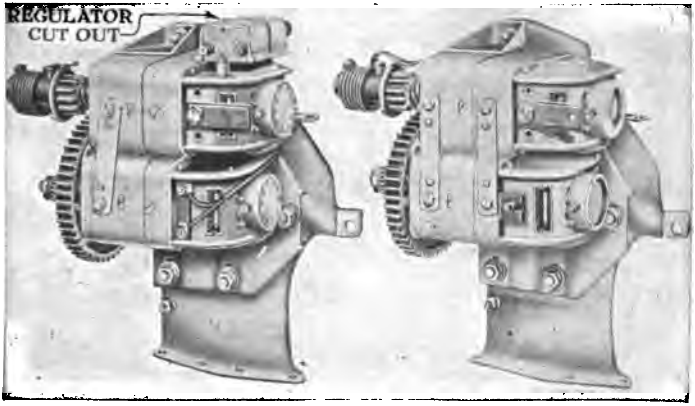


Fig. 24—Two types of Gray & Davis system for Ford car. The generator unit shown at left has electromagnetic regulation, while that at right has third-brush regulation

In the third-brush type of generator, the shunt-field winding is connected between one of the main brushes and what is called a third brush. This third brush is located on the commutator between the positions for two of the main brushes, and the voltage between it and the main brush, to which the field winding is connected, is some fractional part of the total voltage between the terminals, and the value of this voltage, which is acting on the

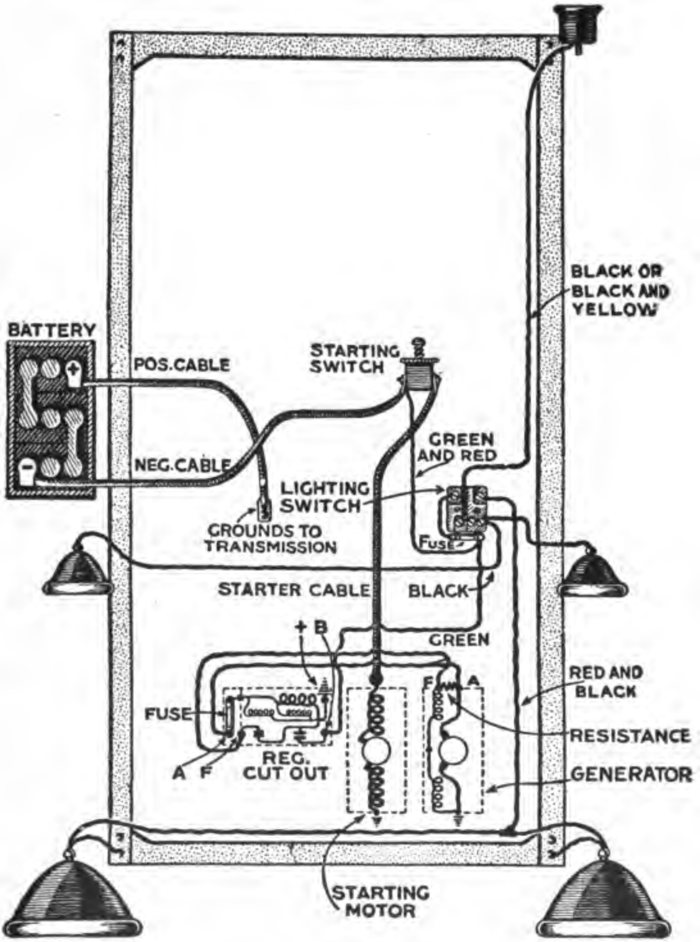


Fig. 25—Wiring diagram of Gray & Davis electric starting and lighting system on Ford, electromagnetic regulation

shunt-field winding, changes when the armature is carrying a current due to the twisting of the magnetic field of the generator in the direction of rotation of the armature.

The two types of generator differ somewhat in outward appearance, and the inexperienced person may determine the type he has by the two external views shown in Fig. 24. The machine shown at the left has electromagnetic regulation and the one to the right has third-brush regulation. The wiring diagram shown in Fig. 22 is for the generator having third-brush regulation, and the wiring diagram shown in Fig. 25 is for the generator having electromagnetic regulation.

Generator with Electromagnetic Regulation

The generator, regulator and cut-out all may be tested by observing carefully the indications of the ammeter for all conditions of operation. Turn the lights all off and run the engine, increasing the speed very gradually.

If the ammeter remains at zero until the engine speed has increased to an equivalent of approximately 7 to 8 miles per hour and then indicates a charging current, it is proof that the cut-out is closing at the proper time. Continue to increase the speed of the engine, and the current should increase until reaching 8 to 12 amperes at an engine speed of approximately 12 to 13 miles per hour. The current should remain practically constant for all higher speeds of the engine, which indicates that the electromagnetic regulator is operating properly. Should the current continue to increase to any great extent after the engine has attained a speed corresponding to 14 to 15 miles per hour, or if the current is abnormally low when the speed is increased, it indicates that the electromagnetic regulator is not operating properly and should be adjusted, which will be described later.

Decrease the engine speed gradually and if the current decreases in value and when reading 0 to 2 amperes discharge returns to zero while the engine is slowed down still further and brought to rest, it indicates that the cut-out properly is disconnecting the battery from the generator before the generator stops.

If the ammeter indicates several amperes' discharge before returning to zero or should continue to show discharge and not return to zero as the engine is brought to rest, it indicates that the cut-out is sluggish or that the cut-out points are stuck together.

The proper adjustment of the cut-out is given in one of the following sections.

If the ammeter does not indicate any charging current at all when the engine is speeded up, determine whether the generator or the cut-out is at fault. Examine wires between generator and regulator and cut-out, also between generator and battery. Examine brushes and cam insulator. Run engine at speed of approximately 12 miles per hour, lights turned off, and while engine is running connect a wire from generator terminal A in Fig. 25, which is the lower terminal on the side of the machine, to the terminal B on the cut-out which is the terminal to which the green wire is connected. If the ammeter then indicates charge and does not indicate charge when points A and B are not connected together, the cut-out is at fault. If the ammeter shows neither charge nor discharge when the points A and B are connected together, the generator is at fault. Carefully inspect the machine to see that the field wires are not injured, that all wires are installed properly and firmly connected to their proper terminals and that the bearings and brushes are not excessively worn.

Generator with Third-Brush Regulation

Turn the lights off and run the engine, increasing the speed very gradually. If the ammeter shows no indication of current until the engine has reached a speed equivalent to approximately 7 to 9 miles per hour and then indicates a charging current, it shows that the cut-out is closing the circuit properly. Continue to increase the engine speed, and the current should increase in value to 12 to 15 amperes at an engine speed equivalent to approximately 13 to 18 miles per hour. Now as the speed of the engine further is increased, above perhaps 18 miles per hour, the charging current should decrease in value to approximately 10 amperes for the high speeds.

Decrease the engine speed gradually and if the current decreases in value and when reaching a value of 0 to 2 amperes discharge the pointer returns to zero while the engine is slowed down still further and is brought to rest, it indicates that the cut-out is opening the circuit at the proper time. If the ammeter should indicate several amperes discharge before returning to zero or should continue to show discharge and not return to zero when engine is stopped, it indicates that the cut-out is sluggish or that the cut-out points are stuck together.

If the ammeter does not indicate charge at all when the engine is speeded up, determine whether the generator or cut-out is at fault as explained in the latter part of the previous section.

Combined Regulator and Cut-out

The interior of the combined electromagnetic regulator and cut-out is shown in Fig. 26. The principle of this device is quite simple and its operation may be explained as follows: Coil 3 is a fine wire or shunt winding. The circuit of this winding may be traced in Fig. 25, starting with terminal A, to the terminal of the fuse marked A, through the fuse and small-wire winding just to the right of the fuse, thence to the ground connection marked + and through the generator armature to the point A from which you started. The current in the winding will vary in value as the electrical pressure generated in the armature of the machine varies in value, and the magnetic effect of this current when it has reached a sufficient value will attract the iron armature 7, Fig. 26, which operates regulator points 5. These regulator points are shown just to the right of the terminal F, on the regulator cut-out in Fig. 25, and when they are closed, the resistance between the points F and A on the generator is shunted through the following circuit. From A

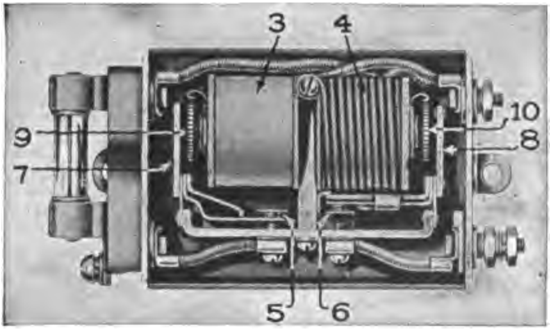


Fig. 26—Interior of Gray & Davis combined electromagnetic regulator and cut-out

on the generator to A on the regulator cut-out through the fuse, through the heavy winding shown on the upper right-hand corner of the regulator-cut-out, thence to the regulator points, to the terminal F on the regulator-cut-out and then to the terminal F on the generator. The regulator joints are adjusted by turning knurled screw 9, Fig. 26, which regulates the gap between parts 7 and 9. Decreasing the gap decreases the output and increasing the gap increases the output. The larger the gap, the smaller the fractional part of the total time that the regulator points short-circuit the resistance connected between the points A and F on the generator, as shown in Fig. 22. This resistance is in series with the field winding of the generator and as the length of time it is in circuit is increased, the value of the average field current will be decreased and hence the field strength will be lowered, which will cause a decrease in the electrical pressure generated in the armature winding, and hence a decrease in the current delivered by the machine. Increasing the fractional part of the total time that the resistance is short-circuited will increase the value of the average field current, and, as a result, the output will be increased..

Electromagnet 4 in Fig. 26 has two windings, a coarse winding and a fine winding. The fine winding is connected in parallel with the winding on the regulator coil as shown in Fig. 25, and the coarse winding is connected in series with the generator and battery when the cut-out contacts are closed. The magnetic pull on the armature 8, Fig. 26, when of sufficient value, draws up the armature and closes the cut-out points 6. The cut-out points are adjusted by turning knurled screws 10. Turning this screw to increase the gap causes the cut-out points to close earlier and stay in longer. Increasing the gap causes the cut-out points to close later and open earlier.

Adjusting Cut-out and Regulator

Before attempting to adjust either the cut-out or the regulator, make sure that the remainder of the electrical system is in proper operating condition, all connections are tight, brushes adjusted properly, commutator clean, etc. A reliable ammeter always should be connected in series with the red and green wire leading from the fuse on the cowl to the starting switch. It is not advisable to rely upon the readings of the ammeter on the dash if an ammeter has been installed.

To adjust cut-out, gradually speed up the engine and watch the ammeter to determine the value of the closing current. The closing current is the reading on the ammeter at the instant the cut-out points close. If the ammeter does not indicate between 1 and 3 amperes when the cut-out points first close, turn adjusting nut 10, Fig. 26, to bring the reading between 1 and 3 amperes with the lamps turned off. Gradually slow down the engine and observe the reading of the ammeter when the cut-out points open. The ammeter should indicate between ½ and 2 amperes discharge when the points open. By repeating this operation a few times, an adjustment can be found which will give satisfactory results. If the cut-out points are not clean, a piece of paper should be drawn between them, at the same time pressing them together with a slight pressure. If they are roughened, a piece of very fine sandpaper may be used in smoothing them off. Be sure to clean thoroughly the points after using the sandpaper and be extremely careful not to bend the springs supporting them as this will cause serious trouble, as you will then be unable to make a satisfactory adjustment.

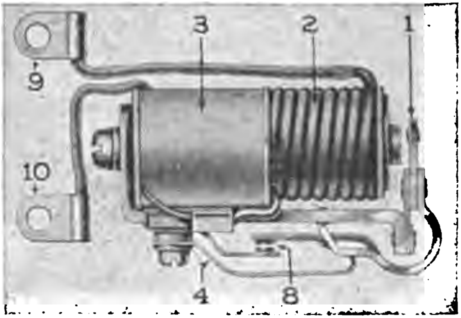


Fig. 27—Gray & Davis cut-out used with third brush type of generator

The operation of the regulator should be such that the ammeter will indicate approximately 9 to 10 amperes at all speeds higher than the speed corresponding to 12 to 13 miles per hour. If the ammeter indicates a current very much less than this amount, adjustment of the regulator may be necessary, especially if the battery has a tendency to run down gradually. If the ammeter shows more than 14 to 15 amperes when the engine is speeded up, the regulator points should be adjusted.

The regulator points should be cleaned thoroughly as in the case of the cut-out points. The engine should be operated at a speed equivalent to approximately 18 to 20 miles per hour, and the knurled screw 9 in Fig. 26 turned so that the current is about 9 amperes. The adjustment may have to be repeated several times before altogether satisfactory results are obtained. It is always best to have the battery fully charged, if possible, when making the above adjustments of the cut-out and regulator.

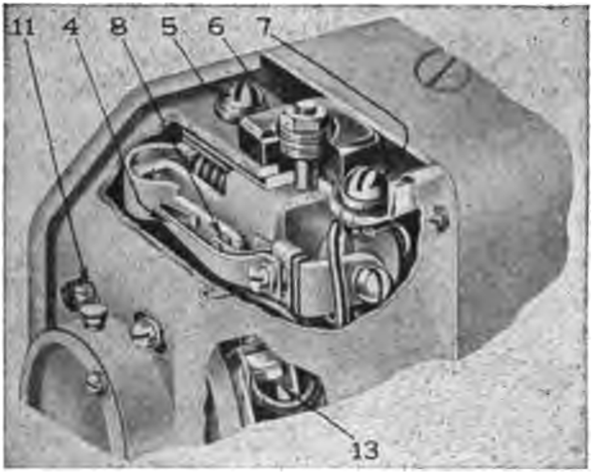


Fig. 28—Part of housing on Gray & Davis third-brush generator cut away, showing method of mounting cutout

After both the cut-out and regulator have been adjusted, each should be given a final test to make sure that the adjustment of the last one has not interfered with the adjustment made in the first one. If any change in adjustment is found to have taken place, the necessary changes should, of course, be made.

Cut-Out On Third-Brush Type of Generator

The cut-out used with the third-brush type of generator is shown in Fig. 27, and the complete cut-out located in the housing of the generator is shown in Fig. 28. There are two windings on the iron core of the cut-out as shown at 2 and 3 in Fig. 27. The electrical connections of these two windings are shown diagrammatically in Fig. 22. The heavy winding 2 is connected in series with the generator and battery, while the fine-wire winding is connected across the terminals of the generator in such a manner that the current taken by the fine-wire winding passes through the coarse-wire winding. As the speed of the generator increases, there is an increase in the value of the generated electrical pressure in its armature winding, and, hence, there is an increase in the value of the current in the fine-wire winding, since the winding is connected permanently in circuit. When the magnetic pull exerted by the current in the fine-wire winding has reached such a value that it will pull over the armature 1, Fig. 27, the cut-out contacts 8 will be closed and the circuit between the generator and battery will be completed. If the electrical pressure of the generator is greater than the electrical pressure of the battery, the battery will start to charge and the current will pass through the coarse-wire winding 2 in such a direction that the magnetic action of this current assists the magnetic action of the current in the fine-wire winding and the armature 1 is held firmly in position and the contact points are closed. As soon as the electrical pressure of the generator drops below the pressure of the battery, due to a decrease in the speed of the engine, the battery starts to discharge and the current from the battery flows through coil 2 in the opposite direction to what it did when the battery was

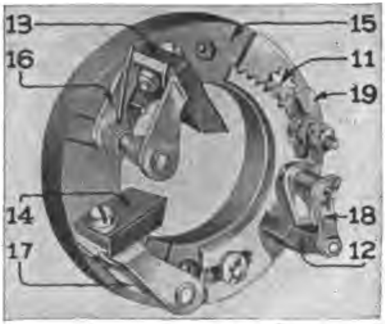


Fig. 29—Brush supporting yoke and brushes for Gray & Davis third-brush generator

charging and hence its magnetic action opposes the magnetic action of the current in coil 3. This relation of the two currents reduces the magnetic pull on the armature 1 and permits the spring 4 to open the cut-out contacts 8 and thus prevent a further discharge of the battery through the generator.

The cut-out points should close when the engine is operating at a speed equivalent to approximately 7 to 10 miles per hour, and the ammeter should indicate from 0 to 3 amperes charging current when the points first close. When the engine slows down, the cut-out points should open when the discharge current is from 0 to 2 amperes. When adjustment of cut-out points is necessary, the pressure of spring 4 should be changed until the values of the currents correspond to those given above. Some skill will be required in making this adjustment. Clean cut-out points as described in previous section.

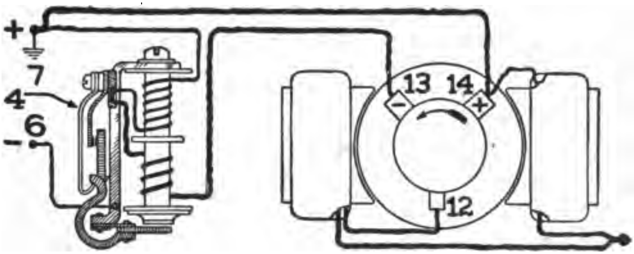


Fig. 30—*Wiring diagram of internal connections of Gray & Davis third-brush generator*

Adjusting Output of Generator

In the third-brush generator the output is regulated by a regulating brush called the third brush. This type of regulator was described in detail in one of the earlier chapters, when the different types of regulation were treated. The Fig. 29 shows the brush-supporting yoke with the two main brushes 13 and 14 and the third brush 12. It is very seldom, if ever, necessary to make an adjustment of the third-brush generator, but when adjustment is necessary it should not be undertaken without the use of a reliable ammeter. The adjustment is accomplished by turning the pinion 11, which is provided with a slot for a screwdriver. A very slight turn will affect the charging rate materially. Turning the pinion to the left increases the output; turning to the right decreases the output. When the generator first is tested, it is run at various speeds from 500 to 3000 r.p.m., and the third brush is so adjusted that the charging rate at any speed will not exceed a definite amount, usually 12 to 15 amperes. The operation of the third-brush type of regulator is such that the output reaches a maximum value and then tapers off for higher speeds. The maximum charging rate should be reached when the engine is running at a speed equivalent to 15 or 18 miles per hour and then decrease to about 10 amperes for very high speeds.

The internal wiring of the third-brush generator is shown in Fig. 30. The field wiring is connected between the positive main brush marked 14 and the third brush marked 12. The two terminals marked + and — respectively correspond to the terminals of the generator as the cut-out is mounted inside the generator housing.

Starting Difficulties

If the starting motor cranks the engine when the starting pedal is pressed to the full limit of its travel and the engine fails to start to run under its own power after, at most, 10 seconds, release the starting pedal and determine the reason for the failure. Any one or a combination of the following troubles may be the cause:

Ignition switch not turned on.
No gasoline in the tanks.
Spark plugs dirty or defective.
Ignition wires not firmly connected.
Cylinders need priming.
Cylinders flooded from too much priming.
Carbureter not properly adjusted.
Dust in carbureter or gasoline pipes.
Poor grade gasoline or water in gasoline.

If the starting motor fails to crank the engine when the starting switch is operated, it may be due to a weak or discharged battery. If the lamps dim excessively when starting switch is operated, it shows that the battery practically is discharged, or perhaps the battery cables are not connected firmly to the battery terminals and transmission case, or there is a poor contact in the starting switch, or the engine may be very stiff. If the lamps remain bright, that is, do not dim at all when the starting switch is operated, it shows that the starting circuit is open. Examine all parts of the circuit for an open circuit or poor contact. It may be necessary slightly to bend the blades in the starting switch in order that a good connection may be made. Examine the starting motor brushes. If excessively worn, they will not make firm contact with the commutator. If the commutator is dirty or rough it should be cleaned thoroughly and wiped with a rag on which there is a little vaseline.

If pressing the starting pedal to its full limit fails to rotate starting motor, release the starting pedal and determine the cause which may be due to any one or a combination of the following:

Battery very weak or completely discharged.

High resistance in motor circuit due to loose connection or poor contact in switch or at brushes.

Motor may be short circuited by cable being in contact with some metal part of the car.

The starting pinion may be wedged so that motor armature is not free to operate.

CHAPTER IV

Westinghouse System for Fords

THE Westinghouse starting and lighting equipment for the Ford car is a single-unit, 12-volt, single-wire system. The regulation of the generator is by the third-brush method.

Preparing Engine for Mounting

Check all the material to see that there are no parts missing. Adjust the ignition and carbureter so that the engine is running smoothly before dismantling any part of the engine. Remove the radiator and both water connections, the three forward left-hand cylinder bolts, as shown in Fig. 31, the fan and its bracket complete, and the Ford timer. Turn the engine crankshaft so that the pin in the fan pulley is in a vertical position, Fig. 31, and drive the pin out and remove the starting crank and fan pulley.

Use a bulldozing tool to expand the front end of the engine oil pan, Fig. 32. This tool may be purchased from the Westinghouse company. It is extremely important that at least ⅜-inch clearance beyond the driving sprocket, which is to be mounted on the engine crankshaft, be obtained as shown in Fig. 33. The bulldozing tool should be used with the spacing hub, always next to the engine. The tool is made so that it may be used for right-hand and left-hand operations equally well.

Mounting Crankshaft Sprocket

The crankshaft sprocket is assembled at the factory and adjusted to the proper tension. Dismantle the sprocket. See that the hole in the end of the crankshaft is in a vertical position, and then drive the Westinghouse sprocket hub, Fig. 33, so that the hole in the sprocket hub is in line with the hole in the crankshaft. The sprocket hub must be a tight fit on the crankshaft and should be driven into place by a copper or brass bar as shown

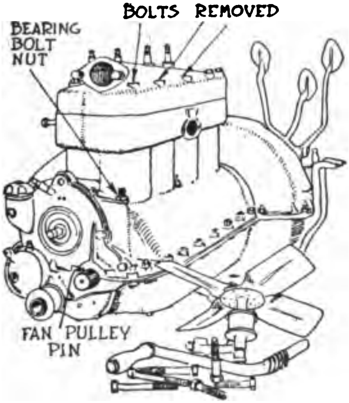


Fig. 31—Ford engine prepared for installation of Westinghouse starting and lighting

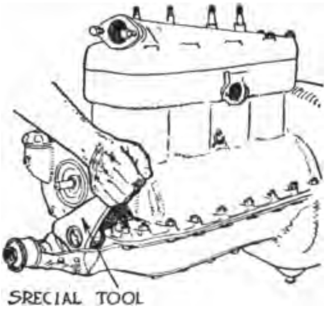


Fig. 32—Method of using special bulldozing tool to expand front end of engine oil pan

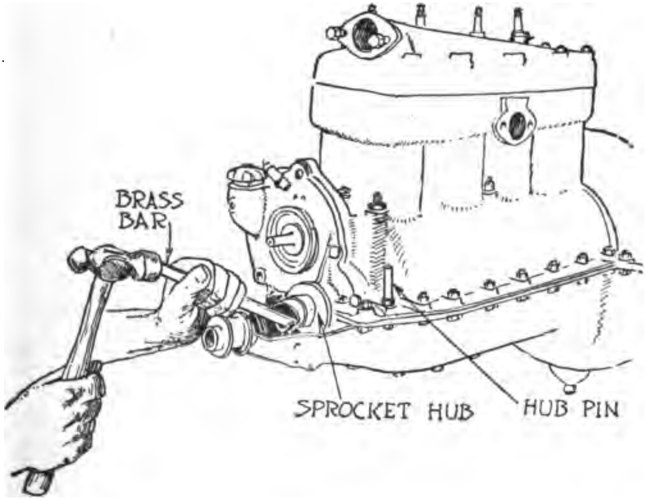


Fig. 33—Mounting the Westinghouse driving sprocket on the engine crankshaft

in Fig. 33. Drive the hub pin, Fig. 33, through the sprocket hub and shaft, and be sure that the headed end is flush with the surface of the hub. If the pin is not a tight fit in the shaft, it should be bent a slight amount at the center so as to make it tight. Use a drift, Fig. 34, for driving the pin into place so as not to injure the pin or hub. To be sure that the pin is not projecting too far at the extended end, place the sprocket on the hub and turn it several revolutions. If the sprocket does not turn freely, the pin probably strikes inside and should be trimmed down until it just clears.

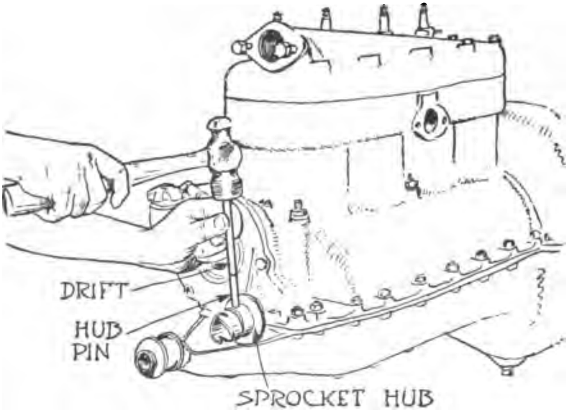


Fig. 34—Method of using drift in inserting sprocket pin in hub

Remove the sprocket and place one of the friction washers, Fig. 35, on the hub. Now spring the spring ring into place on the hub so that the small hole in the ring engages with the projecting end of the small pin. It will not go into place any other way. Be sure that the free end of the spring ring projects at least $\frac{7}{16}$ inch out from the surface of the sprocket hub, Fig. 35.

Place the chain under the sprocket hub. Slide the sprocket over the spring. Pack the sprocket with cup grease and place the other friction washer on the forward side of the sprocket. Now place the stationary washer over the keyway in the sprocket hub, and put the spring washer on the outside of this and fasten it in place with the nut, as shown in Fig. 35. The nut should be tightened until the mark "O" on the nut corresponds with the mark in the keyway on the hub, lower part of Fig. 35. The grooves in the face of the nut should register with the flutes of the spring washer.

Remove the nut from the forward left-hand bearing bolt and replace it with a special flat Westinghouse nut, as shown in Fig. 33. Place the lock washer on top of this nut and screw the cylindrical nut down tightly to the lock washer. Replace the Ford timer.

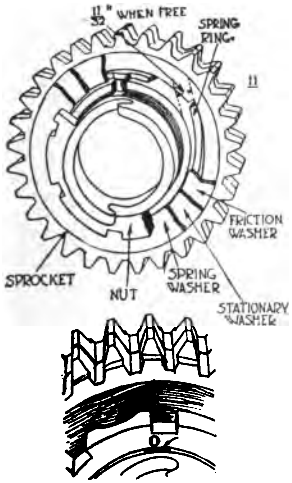


Fig. 35—*Assembly of Westinghouse crankshaft sprocket and its adjustments*

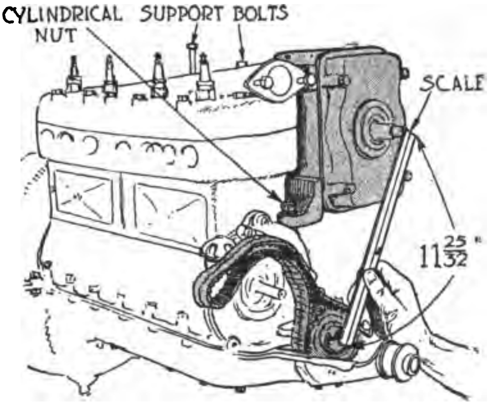


Fig. 36—*Adjusting the distance between the centers of the crankshaft and the shaft of the electrical unit. This distance should be exact*

Mounting Electrical Unit

Set the Westinghouse electrical unit, Fig. 36, in place on the engine, using in the cylinder head the three special screws furnished for this purpose and the special cylindrical nut provided. Adjust the center distance between the engine crankshaft and the shaft of the electrical unit, as shown in the figure. This distance should be $11\frac{25}{32}$ inch as shown, and all three points of support should touch.

Remove the sprocket from the shaft of the electric unit, Fig. 37. Insert the sprocket in the endless driving chain and press the sprocket on the shaft as shown in the figure. When the sprocket is in place there should be at least 10 pounds tension on the chain. If the tension on the chain is less than 3 pounds, adjust the center distance as directed in the following paragraph until required tension is obtained.

A new silent chain is elastic to some extent and for this reason a new chain is adjusted to run at about 10 pounds tension. After several hundred miles of running, the chain may be loosened so that it strikes the chain guard. This is a sure warning that it is time to tighten the chain and it should really not be allowed to run until this occurs. Loosen the three bolts, Fig. 38, about one full turn from the top supporting bracket. Tighten the adjusting bushing nearest the radiator until chain tension is correct, and then set other bushing to agree and tighten all support bolts. Do not run the chain under tension after it has been stretched. If the chain is too tight it will

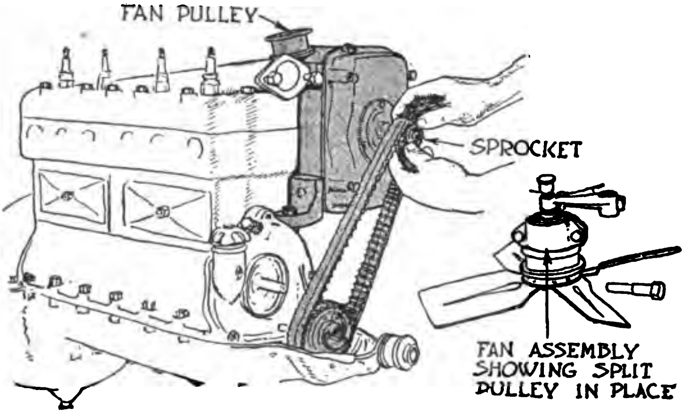

FAN PULLEY
SPROCKET
FAN ASSEMBLY SHOWING SPLIT PULLEY IN PLACE

Fig. 37—Placing the sprocket on the electrical unit with the chain in place on both the sprockets, and fan assembly

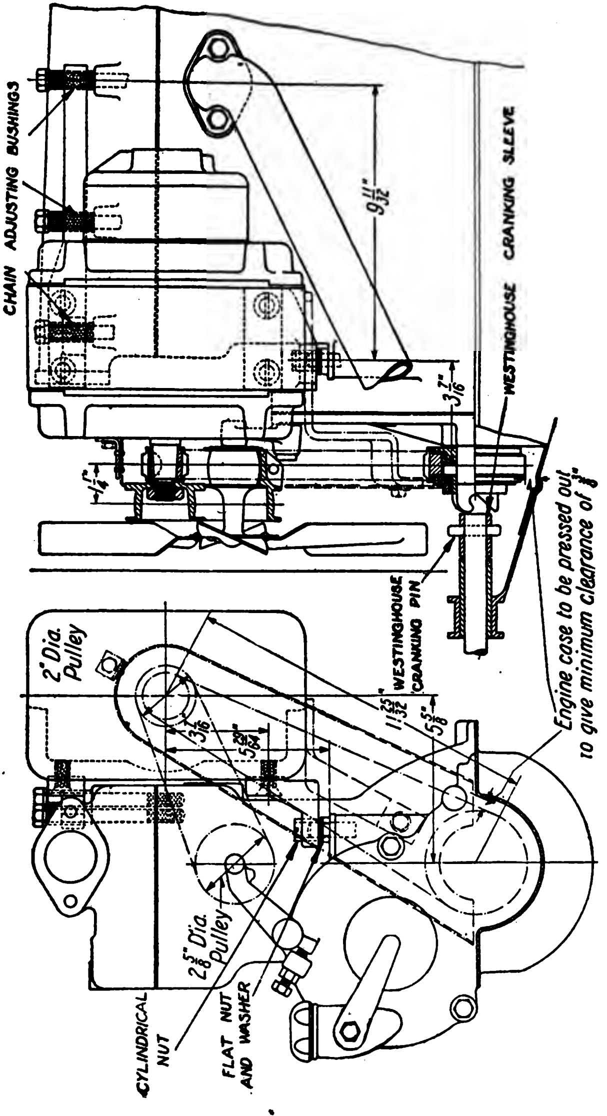


Fig. 38—End and side views of Westinghouse starting and lighting installation on the Ford engine, showing the correct position of the different parts on engine

produce a grinding noise. When properly adjusted, after the chain has been in service for at least 2,000 miles, it should give about ⅜ to ½ inch when pressed upon with the fingers.

After replacing the fan pulley and tightening the nut, be sure to replace the cotter pin, Fig. 39. Mount the chain guard in place and see that it lines up, as shown in Fig. 40.

Clamp the split fan pulley on the Ford fan pulley as shown in Figs. 37 and 38, and replace the fan on the engine, using the new fan belt. The fan blades should be bent slightly so as to clear the pulley on the electric unit. Instead of the Ford ratchet clutch and pin, use the Westinghouse sleeve and pin respectively as shown in Fig. 38. When the Ford starting crank is replaced it may be found slightly out of alignment. If so, insert a bar in the starting crank bearing and spring the bearing into alignment. This completes the installation of the electrical unit itself.

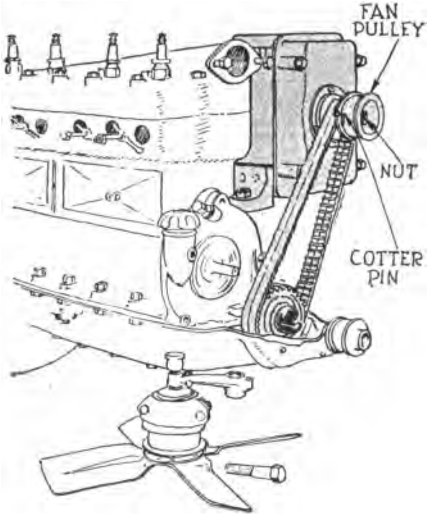


Fig. 39—Shaft pulley in place, lightening the mounting bracket

Installation of Switches and Battery

Mount the Westinghouse two-gang lighting switch on the right-hand side of the dash, as shown in Fig. 40. Cut a rectangular hole in the dash at a point low enough so that the carbureter-adjusting rod will not touch the contact screws of the switch when it is fastened in place by four wooden screws through the cover plate on the face of the dash. Mount the fuse just below the lamp switch on the engine side of the dash as shown in the figure. On Ford cars with the cowl dash, it may be necessary to change the position of the speedometer slightly to provide space for the lamp switch.

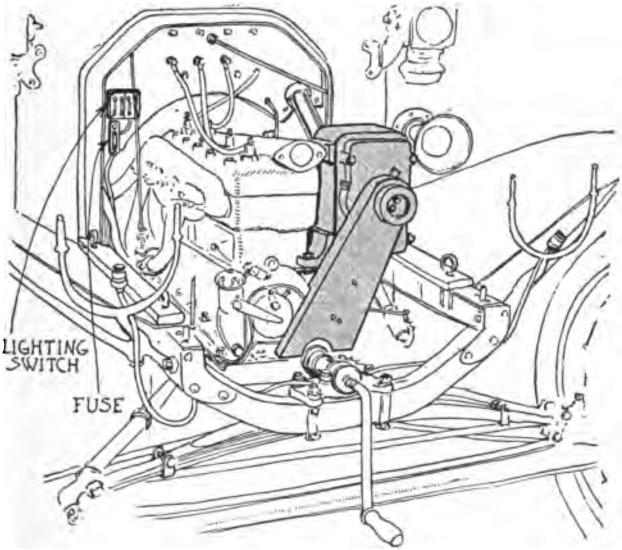


Fig. 40—View of Westinghouse installation on the Ford car, showing chain guard in place and part of the wiring

The starting switch and hand generator cut-out should be located on the heel board at the left-hand side of the car, approximately 2 inches from the car frame, as shown in Fig. 41. The terminals should be toward the right-hand side of the car.

Mount the battery box on the right-hand running board, as shown in Fig. 42, and drill two ¾-inch holes in the splash plate to match the holes in the battery box. Place the battery in the box as shown in Fig. 43, and fasten it in place with the holding-down bolts.

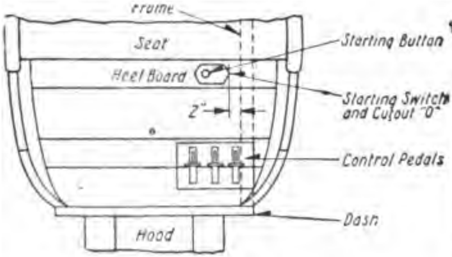


Fig. 41, above—Diagram showing location of Westinghouse starting switch and cutout on Ford car

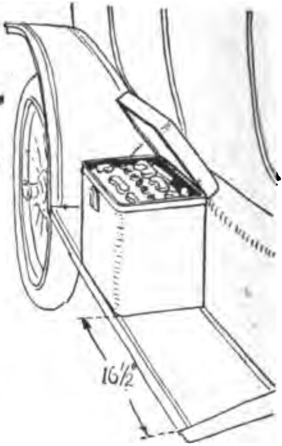


Fig. 42, right—Location of battery box on running board of Ford car, Westinghouse installation

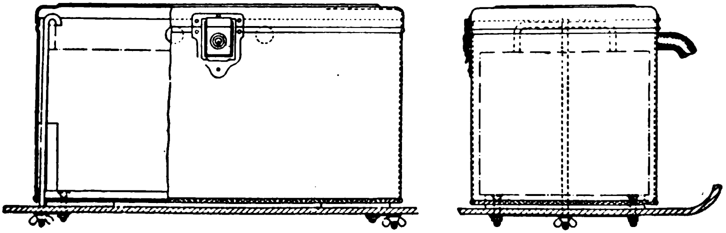


***Fig. 43**—Side and end views of battery box mounting on running board of Ford car, Westinghouse installation*

Installing the Wiring

The wiring should be fastened in place as shown in Figs. 44 and 45. If Westinghouse lamps are used, the dimmer should be removed. All the holding cleats should be fastened under

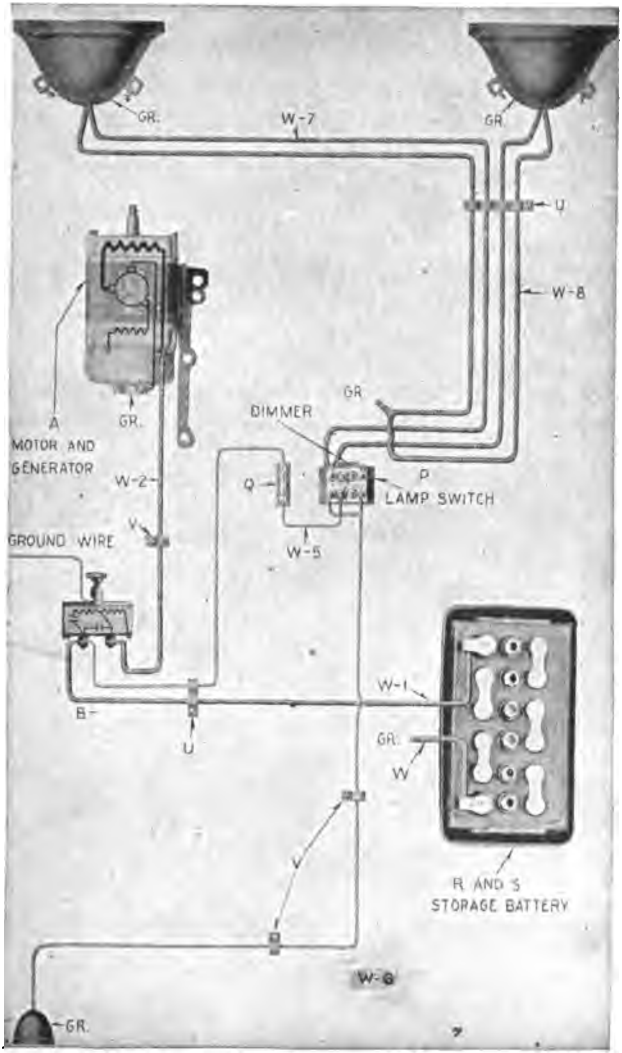


Fig. 44—Wiring diagram of Westinghouse system on Ford car with other than Westinghouse lamps

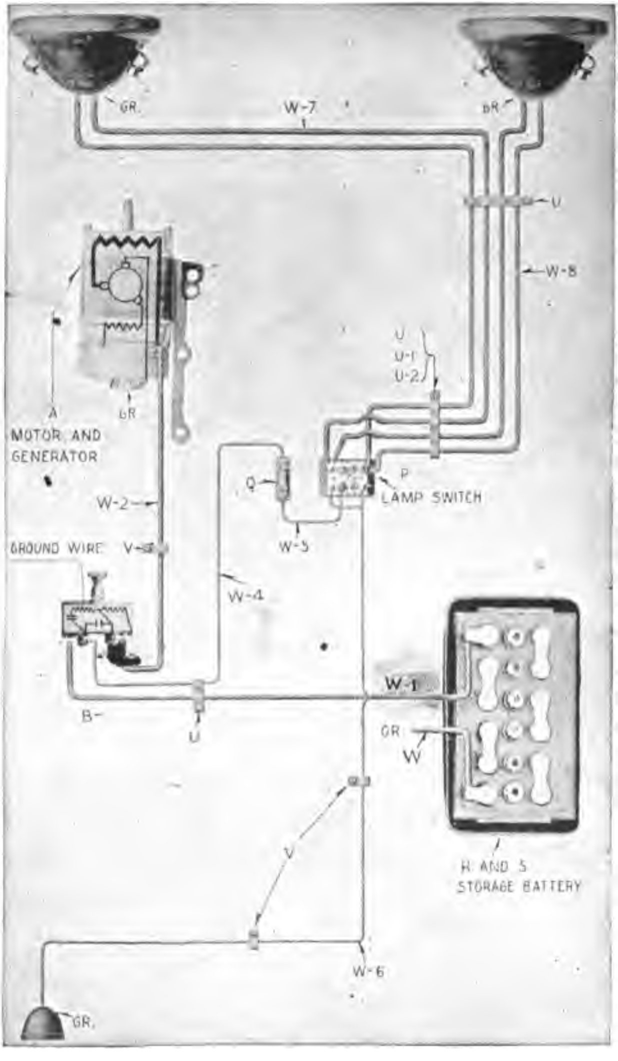


Fig. 45—Wiring diagram of Westinghouse system on Ford car with Westinghouse lamps installed

bolts already on the Ford chassis, except where wood screws may be used to attach the holding cleats to wood parts. Be very careful that the various cable terminals do not touch any part other than the stud to which they are supposed to be fastened. Failure to observe this precaution may result in the apparatus being seriously damaged or the battery ruined before the car is ever run. It is equally essential to prevent the metal armor on the cables from touching any of the connecting studs or terminals. The ground wire should be fastened at one end under one of the supporting bolts of the starting switch and cut-out and at the other end by fastening the connection, together with the cleat for W-2, under the bolt holding the brake and clutch rod to the frame. Do not connect the ground wire W from the battery until all other wires are in place and fastened. The ground connection W is made by fastening the connection under the bolt of the muffler support.

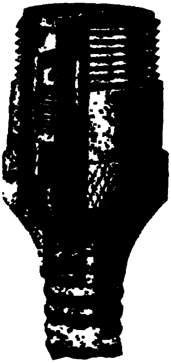


Fig. 46—Details of Westinghouse lamp

Attach the lamp connectors to the wires. These connectors, as made by the Westinghouse company, are of the solderless type. To connect remove the connector from the lamp. Slip the casing, see A in Fig. 46, back over the cable and push the wires through the collar B. Remove the insulation from the ends of the wires for a distance of about ¼ inch. With a small screwdriver applied to the sleeves D, remove the little metal socket C from the connector. Insert the bare ends of the wires into the holes in the socket, and fasten them with the small set screws. Replace the socket and fasten it by screwing up on the sleeve D. Be sure that none of the strands of bare wire projects outside of the insulating piece E. Attach the head and tail lamps, insert the connecting plugs and try all circuits to determine that everything is operating satisfactorily.

When Westinghouse Ford electric headlamps are used, Fig. 45, connect as shown in the diagram, grounding one wire from each lamp socket, also one wire from the tail-light socket. One switch button will give dim lights, and the other switch button will give bright lights. If two-wire double-bulb lamps are used, one wire from each lamp socket must be grounded to the lamp housing or car frame, as shown in Fig. 44, and the dimmer should be disconnected. If side lights are used instead of double-bulb headlights, with two-wire lamps, both wires in cables W-7 and W-8 can be used for the headlights, as shown in Fig. 44, the dash end of one wire in each cable being grounded instead of connecting to the switch. An additional wire should be run from the switch to one terminal of each side lamp, and the other terminal of the lamp grounded. The dimmer should be disconnected. If side lights are used instead of double-bulb lamps, with single-wire lamps, both ends of one wire in cable W-7 and W-8 are useless and should be taped. An additional wire should be run from the switch to each side lamp, and the other terminal of the lamp grounded. The dimmer should be disconnected.

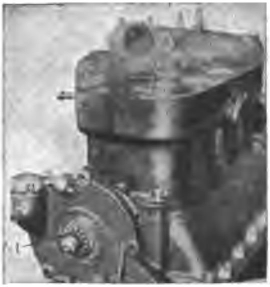


Fig. 47—First step in installation of Westinghouse ignition unit on Ford car

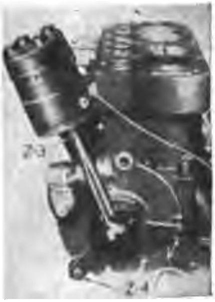


Fig. 48 — Westinghouse ignition unit mounted on Ford car

Installing Westinghouse Ignition on the Ford

Remove the Ford timer and timer rod, Ford ignition coil and all ignition wiring. Remove the Ford timer roller and the spark plug from cylinder No. 1, nearest the radiator.

Place the Westinghouse gear Z-1 on the camshaft in place of the Ford timer roller and fasten it in place with the same pin, cap and nut used in holding the roller, as shown in Fig. 47. Turn the engine until the piston of cylinder No. 1 is at the exact center of the firing stroke, that is, when the piston has come to the top of the cylinder with both the inlet and outlet valve closed. The position of the piston and the valves may be seen through the spark-plug hole.

Mount the ignition unit in the supporting bracket and put the holding screw Z-3 in place. Be sure that the ignition unit turns freely in the bracket. Remove the distributor block from the top of the ignition unit and slide the ring cover up. Turn the entire unit until it is in the position shown in Fig. 48. Hold the unit firmly in this position and turn the distributor-brush arm counter-clockwise to the left until the contact brush is in the position shown in Fig. 48, and the interrupter contacts are just beginning to open. Now clamp the unit in place on the engine exactly in this position. Use the two special screws Z4 to hold the bracket in place on the engine. Turn the engine over by hand to make sure

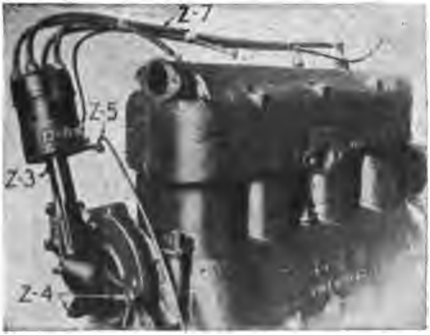


Fig. 49—*Connection of timer rod and arrangement of high-tension wiring of Westinghouse ignition unit on Ford car*

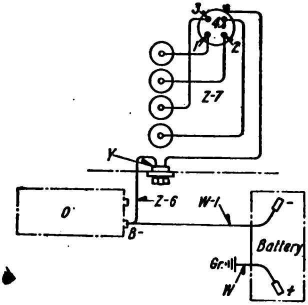


Fig. 50—*Connections for Westinghouse ignition unit for Ford single-pole non-reversing switch* that the bevel gears are meshing correctly and not binding in any position.

Connect the timer Z-5, furnished with the Westinghouse equipment, to the ignition unit as shown in Fig. 49. Operate the spark lever on the steering post and see that the ignition unit follows the movement of the control lever and does not tend to bind in any position.

Mount the cover plate on the dash over the holes left by the removal of the Ford coil unit, and cut a rectangular hole in the dash to receive the Westinghouse ignition switch. Fasten the cover plate and ignition switch to the dash with the screws supplied for that purpose. Place the distributor block on the ignition unit and connect the wires to the spark plugs as shown in Figs. 49 and 50. Be very careful to connect each plug to the point shown in the diagram. Connect one end of the small wire Z-7 to the terminal on the side and near the bottom of the ignition unit that has no other connection, and connect the other terminal of the wire Z-7 to the ignition switch. The terminal Y on the ignition switch should be connected to the negative terminal of the battery, which may be done by running a wire to the terminal B- on the cut-out O, as shown in Fig. 50. The ignition circuit is completed through ground or the chassis of the car when the ignition switch is closed.

Fig. 51—*Front and rear views of Westinghouse ignition switch*

There are three terminals provided for reversing the direction of current through the interrupter contacts. Changing the short connection from one side of the center to the other side, and changing primary wire reverses the current through the interrupter contacts.

The ignition switch is a simple single-pole switch used in connecting the primary terminal of the ignition unit to the negative terminal of the battery. A front and rear view of the switch are shown in Fig. 51, and it may be used to reverse the direction of the current through the interrupter contacts as follows: Remove the metal strip that connects two of the three terminals on the ignition unit together. Remove the metal strip that connects two of the four switch terminals together and make connections between the switch and ignition unit as shown in Fig. 52.

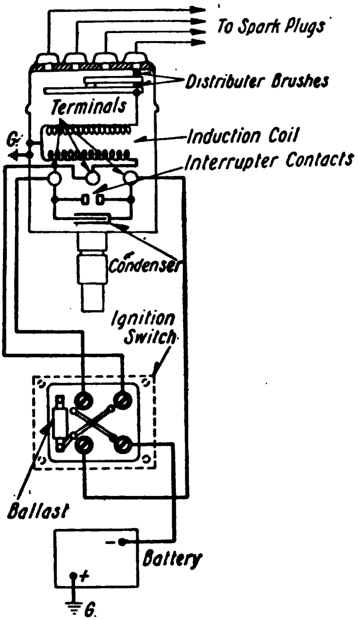


Fig. 52—*Connections between ignition switch and unit so direction of current in interrupter contacts can be reversed*

Starting and Lighting Unit

The Westinghouse electrical equipment for the Ford car is a 12-volt, single-unit, single-wire type in which the unit is connected permanently to the engine by a silent-chain drive. The driving sprocket on the engine crankshaft has a cushioned positive drive in the starting direction, that is, when the sprocket tends to turn faster than the crankshaft and a friction drive in the generating direction. The friction of this drive is adjustable for wear without removing any part of the equipment, as described in the section on failure of generator.

A battery cut-out, or magnetic switch as it is sometimes called, is connected in the circuit between the generator and the battery This switch connects the battery to the generator automatically when the engine is running at a speed equivalent to approximately 9 miles per hour on direct drive or high speed. When the engine is connected to the rear axle through the gears, the cut-out closes at a much lower speed of the car in miles per hour. If no lights are turned on when the cut-out closes, the battery will immediately start to charge, provided voltage of the generator exceeds the voltage of the battery which should be the case if all adjustments are properly made. If the lamps are turned on and cut-out closes, the battery may not start to charge until the car speed has reached perhaps 15 miles per hour, as the generator first must supply all the current to the lamps before it can start to charge the battery. The current supplied to the battery will depend upon the number and kind of lamps in service and the speed of the engine. Fourteen-volt bulbs should be used in all the lamps. The construction of the starting switch and cut-out is shown in Fig. 53. The electrical connections for the switch and cut-out are shown in Figs. 44 and 45. Two windings are provided on the cut-out. One of these windings, or coils, carries a current which is proportional to the voltage generated by the electrical unit and the other carries the current delivered to the battery by the generator action in the electrical unit and the discharge current from the battery through the electrical unit when the voltage of the battery for any reason exceeds the voltage of the generator and the cut-out contacts happen to be closed. This series winding on the cut-out and the cut-out contacts are short-circuited by the starting-switch contacts when the starting switch is closed and there is a heavy discharge

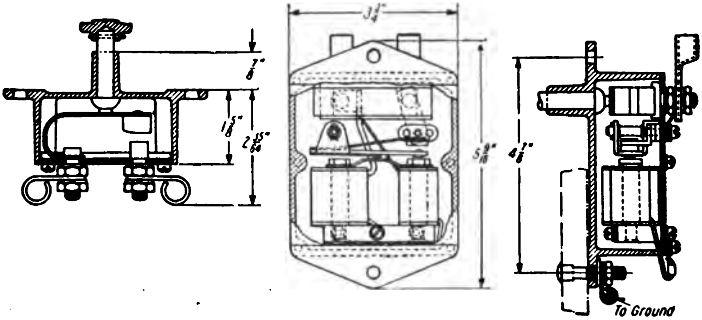


Fig. 53—Construction of Westinghouse starting switch and cut-out for Ford installation

current from the battery through the electrical unit which now is operated as a motor.

The internal electrical connections of the electrical unit are shown diagrammatically in Figs. 44 and 45. There are two windings on the magnetic circuit of the machine, one a heavy winding of relatively few turns, connected in series with armature winding, and the other a finer winding of relatively large number of turns, connected from a third brush to ground, which electrically is one terminal of the machine. When the machine is operating as a generator its output is regulated by a combination of the third-brush and bucking-field principles. When the machine is being operated as a motor the magnetizing action of the large and small field windings assist each other and the combination produces a large starting torque. The armature of the machine tends to rotate in the same direction when used as a motor that it rotates in when used as a generator and driven by the engine.

The cap oiler on the back end of the electric unit should be given three or four drops of oil about once every month. Always use the best quality of machine oil for this purpose.

Examine the commutator occasionally by removing the spring collar over the brushes. Keep the commutator free from dirt or oil. If the commutator becomes roughened its surface may be smoothed up with fine sandpaper held against its surface with a square ended stick of wood. Be sure that the brushes are clean and making good contact with the commutator surface and that they are not worn so as to need replacement. The brushes should not be removed unless they are suspected as being the cause of some electrical trouble in the operation of the system. They may be removed by lifting the spring that holds the brush in the guide and taking out the screw holding the brush shunt, after which the brushes may be slipped out. In removing each brush it should be noted which side was up and each brush should be replaced in its original holder with the proper side up. When new brushes are installed see that they are seated properly on the commutator by grinding them in with sandpaper until this perfect fit is obtained. It is advisable to use brushes obtained from the manufacturers of the equipment, as they have determined by test and experience which kind is best adapted to each particular requirement.

Do not put oil or grease of any kind on any part of the starting switch, as it will cause the switch contacts to become gummed and poor electrical connection will be the result.

If for any reason at all one of the bearings has to be removed and replaced, the adjusting cover plate should be screwed into exactly the same position and the stop inserted in the same hole.

Before cleaning the engine with kerosene or gasoline, be sure to first disconnect the positive, +, battery cable from the battery. If this suggestion is not followed, a spark may be produced by some part of the live circuit coming in contact with a grounded part, which may ignite the gas. Be sure to reconnect the battery when through cleaning.

Several additional fuses should be carried at all times. If any one of the fuses in service is blown, it should not be replaced until the cause is known and remedied. A fuse may blow due to a ground or short-circuit in the wiring or lamp sockets of any of the various electrical circuits. Under no conditions is it advisable to use a piece of wire in place of a fuse, only in a very extreme emergency and not then unless the difficulty with the circuit has been corrected or it is known not to be very serious and no additional fuses are available. Be sure to replace the substitute with a good fuse at the very first opportunity. The current capacity of the fuse should be 10 amperes.

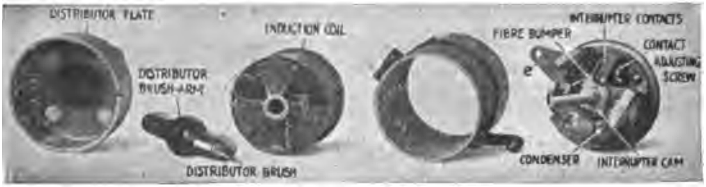


Fig. 54—Essential parts of the Westinghouse ignition for the Ford car

Never run the engine with the battery disconnected. In disconnecting the battery, always disconnect the positive terminal first, and in reconnecting always connect the positive terminal last.

Operation of Ignition Unit

The Westinghouse ignition unit is made up of four essential parts, namely, the interrupter, the condenser, the induction coil and the distributor, Fig. 54, all mounted in one case. The operation of the interrupter may be observed by loosening the thumb screw A, Fig. 55, and sliding the loose section of the insulating case upward. With the ignition switch turned to the "on" position and the engine being turned over very slowly by hand, each segment of the interrupter cam, Fig. 54, in turn passes on and off the fiber bumper. As each segment of the cam passes off the fiber bumper, the interrupter contacts close, thus closing the electrical circuit from the battery through the primary winding of the induction coil. Then as each segment of the cam passes under the fiber bumper, the interrupter contacts are opened, which suddenly opens the electrical circuit, thus causing a high voltage to be induced in the secondary winding of the induction coil. The secondary winding has one of its terminals grounded and the other terminal is connected by the distributor to the insulated terminals of the

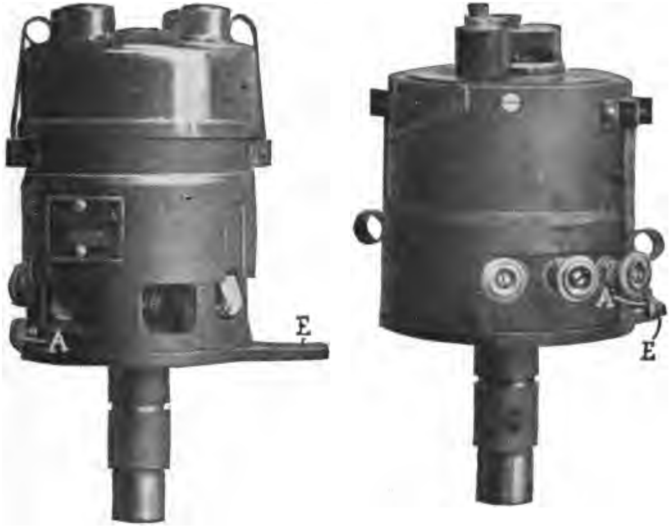


Fig. 55—*Westinghouse ignition unit for the Ford car. At left, interrupter cover raised and distributer plate in position; right, interrupter cover lowered and distributer plate removed* different spark plugs in turn. If the adjustments of the ignition unit are correct, the secondary winding should be connected to some one of the spark plugs at the instant that the primary circuit is opened at the interrupter contacts. The high voltage produced in the secondary winding then will cause a spark between the terminals of the spark gap of one of the spark plugs and thus ignite the charge of gas in the engine cylinder in which the plug is mounted.

The adjustment of the ignition unit should not be disturbed until a thorough search has been made for the trouble and you are positive the difficulty is within the unit itself.

The distance between the points of the spark plugs should be adjusted to .025 inch for the best operation. Missing often will be due to dirty spark plugs, or the insulation of the plug may be cracked. The plugs should be removed and thoroughly cleaned and inspected and the points carefully adjusted.

The carbureter should be adjusted carefully, preferably by a man thoroughly familiar with this kind of work, and his instructions in regard to changing to a richer or leaner mixture, use of heating jackets, etc., should be followed.

Although there seems to be no relation between the water circulation or insufficient cooling of the engine and ignition, yet it may tend to cause pre-ignition, loss of power, and a tendency for one or more cylinders to keep on firing after the ignition is turned off. An excessive deposit of carbon in the cylinders may be the cause of similar results.

The interrupter contacts should be adjusted by turning the contact screw with a screwdriver so that with the cam segments against the fiber bumper, as shown in Fig. 54, the contacts are open .008 inch. The interrupter contact should be inspected about every 1,000 miles running of the car, and the gap space checked with the feeler gage furnished with the outfit. If the contact points are rough or pitted, they should be smoothed off with a very fine file, making certain that the surfaces come together squarely after final adjustment has been made.

The distributor brushes should slide freely in their holder and the spring should push the top brush out so as to extend from the holder about one-quarter inch when the distributor plate is removed The brushes, however, should be retained firmly by their springs so as to never tend to fall completely out of the tube. Be sure that both brushes are in place before pulling on the distributor plate. The surface of the distributor plate should be kept free from carbon dust between the contact surfaces by an occasional wiping with a clean cloth.

When the engine is running with any high-tension lead disconnected from its spark plug, as in the case of a spark plug pump, the disconnected high-tension lead should be grounded to the engine frame. The ignition unit never should be operated with a high-tension lead disconnected from its distributor terminal.

Installation of Voltmeter and Ammeter

A voltmeter may be mounted permanently on the dash of the car and, when properly connected, will indicate at all times the condition of the storage battery. When connecting a voltmeter to the circuit of the Westinghouse Ford system, connect the terminal marked — on the voltmeter to the terminal marked B— on the Westinghouse combined starting switch and cut-out. The voltmeter terminal marked + should be connected to the frame of the car at any convenient point.

If an ammeter is desired it may be connected easily, as provision for connecting one in circuit has been provided on the combined starting switch and cut-out. To connect the ammeter in circuit remove the metal strip between the small terminal and the B— terminal, and connect the terminal marked — on the ammeter to the terminal marked B— on the combined starting switch and cut-out. The terminal marked + on the ammeter should be connected to the small terminal from which the metal strip was taken on the combined starting switch and cut-out.

Location of Troubles

When troubles arise in the operation of an electrical system, it is desirable to locate them as quickly as possible, and to assist in doing this the Westinghouse company has gone to considerable trouble in preparing a general classification of the troubles likely to occur in connection with their system and the causes of each. It is not likely that you will ever experience any particular difficulty and will have no occasion to make use of certain parts of this list of probable difficulties. In each general classification, the most likely cause and at the same time the most easily tested are given first and they should be checked in the order given.

Starting Troubles

If the starting motor fails to start when the starting switch is closed, open up the starting switch and test out the trouble as follows, using a direct-current voltmeter to check with. Connect the voltmeter to the battery terminals or better still as instructed in a previous section and observe its indication of the battery voltage. If it indicates less than 11 volts or the lamps are very dim when turned on, the battery is run down. The condition of the battery can be checked by determining its specific gravity, as previously explained under the section relating to the storage battery.

Next look for an open circuit or loose connection in the wires W, W-1 and W-2, Figs. 44 and 45. Remove the spring collar over the brushes; see that the brushes and commutator are in good condition and not sticky with oil, and the brushes make good electrical contact with the commutator. Examine the contacts in the starting switch to see that the circuit is closed when the switch is depressed.

If the motor still fails to start after this inspection, connect the voltmeter leads to the brushes of the motor and close the starting switch, at the same time observing the voltmeter. If the voltmeter shows no indication the trouble is in the circuit between the battery and the motor. Remove the voltmeter connection from the positive brush and transfer it back to the positive battery terminal and observe the voltmeter reading with the starting switch closed. If the voltmeter gives an indication of the voltage of the battery the trouble is in the circuit between the positive terminal of the battery and the grounded brush of the starting motor. Now remove the voltmeter lead from the positive terminal of the battery and connect it to the frame of the car and observe the voltmeter reading. If the voltmeter does not read the voltage of the battery the circuit from the positive terminal of the battery to the frame of the car is open. If the voltmeter does read the voltage of the battery, the connection from the grounded brush of the starting motor to the frame of the car is open. The circuit leading from the negative terminal of the battery to the starting motor may be tested for opens by connecting one terminal of the voltmeter to the positive terminal of the battery and then moving the other terminal of the voltmeter along the circuit from point to point, starting with the negative battery terminal and observing the voltmeter reading for each separate connection. For example, if the voltmeter indicates the battery voltage with the free terminal connected to the starting-switch terminal to which the wire B— is connected, Fig. 44, but gives no indication when the free terminal is transferred to the starting switch terminal to which the wire W-2 is connected, the starting switch being depressed, it is an indication of an open circuit in the starting switch itself.

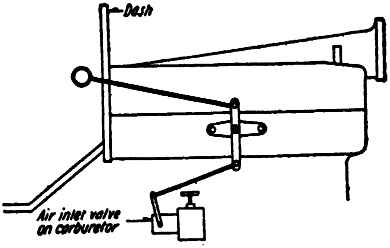


Fig. 56—Method of installing strangler on Ford engine

All these tests may indicate the circuit is closed and that the battery is fully charged yet the starting motor will not operate. The difficulty is then likely due to an extra resistance being introduced into the circuit such as poor starting-switch contact, bad ground connections, etc., and may be tested for as follows: Connect the voltmeter across the part of the circuit you suspect of being in trouble, for example, the starting switch, and close the switch. If there is quite an appreciable reading on the voltmeter the resistance of the switch contacts is too high and should be cleaned and readjusted. Likewise the resistance of the ground connections may be tested by connecting the voltmeter across the ground connection with the circuit closed and observing the voltmeter reading. There will be practically no indication on the voltmeter if the resistance of the ground connection is low, otherwise the ground connection will show a considerable indication depending upon the resistance offered by the ground and the current being sent through the resistance. The resistance of the entire starting-motor circuit between battery and starting motor may be checked by observing both the terminal voltage of the battery and the voltage between the motor brushes when the starting switch is closed. The difference in these two readings is a measure of the voltage used in producing the current through the wires, switch, frame of car and all connections and should be small in value in order that as large a part of the total battery pressure as possible be available for operating the starting motor. Remember that the voltage between brushes of the starting motor and the battery voltage will be the same if the starting switch is closed and the circuit inside the motor is open when the measurements are made and is no indication of a low resistance but instead an open circuit.

If the engine does not pick up immediately after two or three trials, although the starting motor turns the engine at the required speed, the trouble is more than likely due to one of the following causes: Gasoline supply exhausted; dirty spark plugs; faulty carbureter adjustment; ignition system at fault.

If the engine is cold or has not been in use for some time it may be necessary to use the strangler, which reduces the air supply to the carbureter. The installation of the strangler is shown in Fig. 56.

If the lamps in one circuit do not burn, the trouble may be due to the lamp being burnt out or a broken connection in the wiring. Carefully examine all the places where the electrical connections are made on that particular circuit, and try a lamp that you know is O. K. in the lamp socket.

If none of the lamps will burn, and the voltmeter reading, when the instrument is installed as instructed in the section on installation of voltmeter and ammeter, drops to zero with the engine stopped, this may be due to:

(a) The terminals of the battery are disconnected or corroded so that they do not make good electrical contact.

(b) The wire W, Fig. 44, is disconnected or broken. If the voltmeter indication is O. K. the trouble may be due to:

(c) Blown fuse. If the fuse is blown do not replace it immediately but look over the wiring carefully for an accidental ground or short-circuit. In looking for grounds or abrasion of the insulation on the wire or an electrical contact between the ends of the cables or current-carrying parts of the wiring devices and the metal of the car, socket shells, etc., should be examined. When the trouble has been located and corrected, replace the brown fuse with another fuse of the same current capacity. If the trouble on the circuit cannot be located immediately, then turn off the switch on the damaged circuit or disconnect the part of the circuit in trouble by loosening wire from under a screw or disconnecting it, if absolutely necessary, by cutting the wire, and have the difficulty adjusted at the very first opportunity. If the trouble is in a particular lamp socket, disconnect the attachment plug from this socket until the trouble can be removed, and see that the removed attachment plug does not dangle in such a way as to make a short-circuit on the metal of the car.

(d) Wire W or W-1 may be disconnected or broken. If this is the case the starting motor will not operate.

(e) Wire W-4 or W-5 may be disconnected or broken.

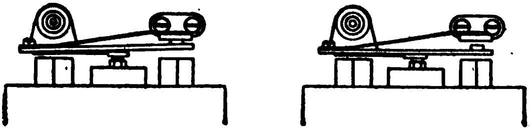


Fig. 57—Opened and closed positions of Westinghouse cut-out switch

(f) The lamps may be burnt out. This is likely to be the case when any of the troubles a, b or d of this section happen.

(g) The battery may be run down.

If the lamps in a circuit go out for an instant only, the trouble is probably due to a loose connection in the circuit so affected. If all the lamps go out for an instant, there is probably a loose connection at one end of the wire W-4 or W-5.

If the lamps are dim when the engine is not running, this indicates that the battery is discharged. If possible, have the battery charged at once from an outside source. It is advisable to check up on the charging rate to see that the battery is being properly charged.

Battery Troubles

The battery may not stay charged and the difficulty may be due to any of the following causes.

(a) The car is not run enough without the lights or at high enough speed for the generator to charge the battery and replace the electrical energy that is drawn from the battery when the lamps are burning with the engine not running or running at very low speed and that used in operating the starting motor and ignition unit.

(b) A ground in the car wiring. With the engine stopped and the lights turned off, disconnect one of the battery wires and touch it lightly on the battery terminal a few times. If a spark is produced there is a ground or short-circuit in the wiring.

The battery may not charge even though the engine is running at a high enough speed, due to one or more of the following causes:

(a) Loose connection between the starting switch and electrical unit. See that the terminals of the wire W-2 are tight, and examine the wire between the terminals for a break.

(b) The magnetic switch, or cut-out, in the generator circuit is not operating properly. Examine the switch and see that it is connecting and disconnecting the generator and battery properly. The switch should be in the open position when the engine is not running, as shown to the left in Fig. 57, or should stay in the closed position, as shown to the right in the figure, when the engine is running at a speed equivalent to a car speed of approximately 9 miles per hour with high-gear connection. The speed at which the cut-out closes of course, varies considerably. If the switch does not close, the generator is not developing sufficient voltage due to the presence of oil on the brushes or commutator, or some of the brushes may be worn to such an extent that they do not make electrical contact with commutator.

(c) The friction sprocket may have lost its tension. With the engine stationary, try to turn the electrical unit by hand in both directions. If it can be turned easily in one direction the nut, Fig. 35, should be tightened sufficiently to enable the engine to drive the electric unit. When running the car at 15 to 20 miles per hour a faint click may be heard about every 5 minutes. If the clicking becomes more rapid than three or four times in 5 minutes, tighten the adjusting nut a third to a half turn.

(d) The shunt-field brush, Figs. 44 and 45, may not make good contact with the commutator. Adjust the brush and if this does not correct the trouble make the following tests: Test out the shunt-field circuit for open connections. If the shunt-field winding is found open-circuited, the trouble was no doubt originally due to an open circuit between the generator and the battery or to running the generator with the battery disconnected.

(e) If the engine turns over slowly after the ignition switch is turned to the "off" position, it is an indication that the generator cut-out is sticking and the battery is discharging through the electrical unit which is now operating as a motor. Should this happen, immediately close the ignition switch and while the engine is running disconnect the wire from the generator and then examine and adjust the cut-out switch.

Ignition Troubles

If the engine fails to pick up the difficulty may be due to failure of the spark, and the following inspections and tests may be made:

(a) See that the ignition switch is in the "on" position and that the wire or wires leading from the switch to the ignition unit are not disconnected or broken.

(b) See that there is gasoline in the carbureter and if there is none it may all be used up, it may not be turned on, or the gasoline feed pipe or valve may be stopped up. If the system is of the gravity feed type the gasoline may not flow into the carbureter on steep hills.

(c) If there is gasoline in the carbureter, take out one of the spark plugs and lay it on the engine with the sparking points in the air but with the threaded part in contact with the engine frame. Turn the engine over by hand or the starting motor, and if there is a spark produced at the plug gap, the trouble is not in the electric system but probably due to poor gasoline, water in the gasoline or the temperature may be too low for the grade of gasoline used.

(d) If the same battery is used for the starting motor and ignition and there is very little charge in the battery, the battery may not be strong enough to produce a spark of sufficient intensity at the same time that the starting motor is drawing current to turn the engine over. Often time in such cases the engine may be started by hand, thus preventing an excessive draw on the battery.

If no spark is produced when you try test c and the battery is not discharged, as indicated by tests in d above, then make the following tests to try and locate the difficulty:

(a) Observe the voltmeter indication, and if with the engine idle it indicates less than 11 volts when the lights are turned off, the battery is run down.

(b) If the lights do not burn when they are turned on, there is probably a loose connection in one of the wires from the battery.

(c) If the lights do burn when they are turned on, try turning the ignition switch "off" and "on" several times and then test for ignition spark again. If the ignition now is found to be all right, there was a poor contact at the switch.

(d) If these tests and suggestions do not remedy the difficulty, there may be a loose connection or broken connection in the various wires running to the ignition switch or in the low-tension wires running to the ignition unit.

(e) If the switch wires and all connections are found in good order, remove the distributor plate and see that both brushes are free in their holder and making good contact. Clean the brushes and contacts inside the distributor plate and try again for the spark.

(f) If these tests have not yet remedied the difficulty, raise the interrupter cover and see that the interrupter contacts touch and separate properly when the segments come in contact with the fiber bumper. If these contacts do not close, if they appear to be dirty or if they separate more than .008 inch, they should be adjusted.

It sometimes happens that the engine is firing on all cylinders, yet it does not develop its usual amount of power. The difficulty is more than likely due to the spark being retarded too much, or too rich a mixture of gasoline.

If the engine misfires on certain cylinders at all speeds, the following tests should be made to determine the difficulty:

(a) Disconnect the spark plug terminal of any one of the cylinders that misfires and hold the end of the terminal about $\frac{1}{32}$ inch from the engine cylinder but not quite in electrical contact, while the engine is turned over. If a spark occurs in the gap between the end of the wire and the cylinder, the trouble is not due to the electric system being out of order but in the spark plug, valves or piston.

(b) If no spark is produced after the above tests are made, examine the spark plugs of the cylinders that are missing to see that they are cleaned, the insulator is not cracked and that the gap is adjusted properly.

(c) If no spark is produced while making tests in (a) the difficulty may be due to the high-tension lead from the distributor terminal to the spark plug being broken, the connector at the distributor may be loose, the wire may be bare and touching some metal part of the frame or engine.

The engine may misfire at either high or low speeds only and in such cases the difficulty is probably due to the following causes. If it misfires at low speeds, the carbureter is more than likely out of adjustment; the plugs may be fouled, or the interrupter contacts may be a little dirty. When the engine misfires at high speeds only, the carbureter adjustment is feeding too rich a mixture into the cylinders, or the interrupter contacts may be too far apart.

Back-firing of the engine is not always due to the ignition system but may be caused by the spark being advanced too far or the engine being out of time.

CHAPTER V

Heinze-Springfield System for Fords

THE Heinze-Springfield starting and lighting system for the Ford car is of the two-unit, 6-volt, single-wire type. The generator and motor are mounted on a special bracket attached to the left-hand side of the engine, the generator being below the motor. The generator is driven by a silent chain which runs over sprockets on the crankshaft of the engine and generator shafts respectively. The motor is geared to the engine, when used in starting, by a Bendix drive, the pinion of which meshes with a large gear on the generator shaft and the same silent chain that is used in driving the generator. One type of generator has a bucking field type of regulation and another type has electromagnetic regulation.

Preparation of Engine for Mounting

Before dismantling any part of the car, check over the bill of material to make sure that every part is on hand. Adjust the ignition and carbureter so that the engine is running smoothly. Remove the following parts, observing the precautions mentioned. Disconnect the radiator by removing bolts on each side, remove the rod, water connections to engine and wires to the headlights. The water outlet pipe should be disconnected from the hose, after the radiator has been removed and discarded. Remove the fan and starting crank, fan belt and fan bracket. Remove the fan pulley from the crankshaft and discard the pulley and pin and cotter pins. Next remove the timer, or commutator, and disconnect the rod from the timer case. Place the commutator case back along the side of the engine after it is removed, but do not disconnect the wires. Remove commutator brush assembly, after noting carefully the exact position of the brush, and do not turn the engine over while the brush is removed. If the brush is replaced care-

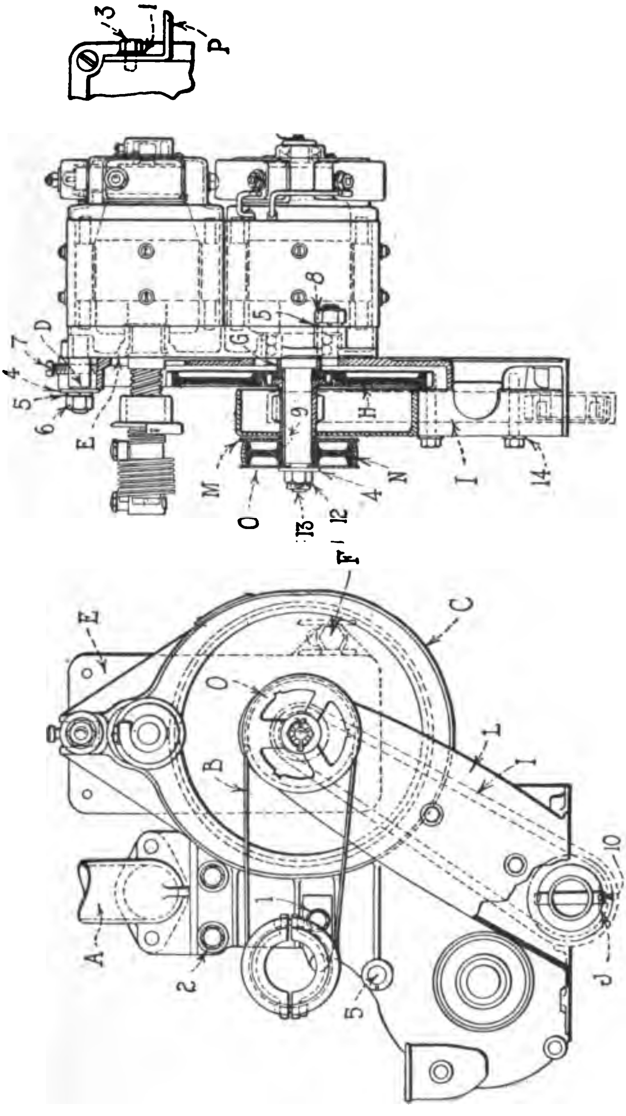


Fig. 58—Front and side views of Heinze-Springfield motor and generator installed on Ford car

fully in its original position when reassembling, the timing of the engine will not be altered.

The timing-gear cover, or cylinder front cover, now should be removed, retaining all the bolts, the nuts, the gaskets and the cotter pins for replacement in mounting the main bracket plate supplied as part of the Heinze-Springfield equipment. It is necessary to remove the felt washers around the openings in this timing-gear cover for the crankshaft and camshaft and place them in the corresponding openings in the new bracket plate which is to take the place of the cover. If the car has seen considerable service, it is advisable to replace these washers with new ones to prevent a leakage of oil from the crankcase.

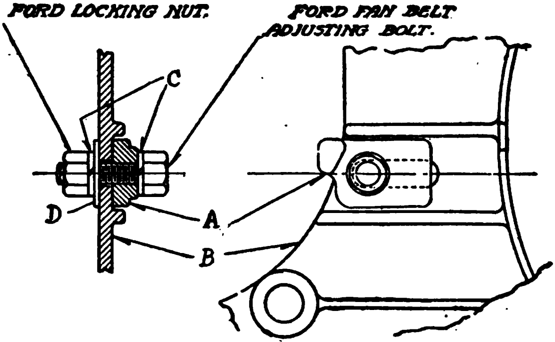


Fig. 59—Correct assembly of belt tightener for Heinze-Springfield installation on Ford car

Secure the Heinze-Springfield water-outlet header, A in Fig. 58, in place on the cylinder head casting, using the original Ford bolts and gasket. Place the fan-belt tightener, A in Fig. 59, with the nose away from the large gear housing, in the slide provided for it on the main bracket plate B. Remove the fan adjusting screw and locking nut from the Ford cylinder front cover and use same, together with the two lock washers, C, and plain washers, D, to secure this tightener as shown in Fig. 59. Set the main bracket plate in position on the Ford engine, and bolt securely in place, using the original Ford paper gasket, cap screws, bolts, nuts and cotter pin. Be sure to tighten all bolts securely to prevent oil leaks. Then bolt the main bracket plate

C to the water outlet header A, using the two, 3, bolts, 1, lock washers and 2, plain washers as shown in Fig. 58. The commutator brush assembly and commutator now may be replaced, taking particular care to put them back in their original position. Connect the commutator advance rod back in position.

Installing the Electrical Units

The combined generator and starting motor unit should be placed in position on the main bracket, plate C, with the chain adjusting stud D in place on the electrical unit, as shown in Fig. 58. The chain adjusting stud D should rest freely in the bottom of the slot at the top of the main bracket plate C. Assemble on this chain adjusting stud D, plain washer, 4, lock washer, 5, nut, 6, and screw, 7. Be sure that the shoulder of the chain adjusting stud D is turned up tight against combined head E. Place the lower adjusting bolt F in the slot provided for it on the main bracket plate C. A lock washer, 5, and nut, 8, are provided for this bolt, and they should be placed in their respective positions. Do not, however, tighten either the upper or lower chain adjusting bolts at this time.

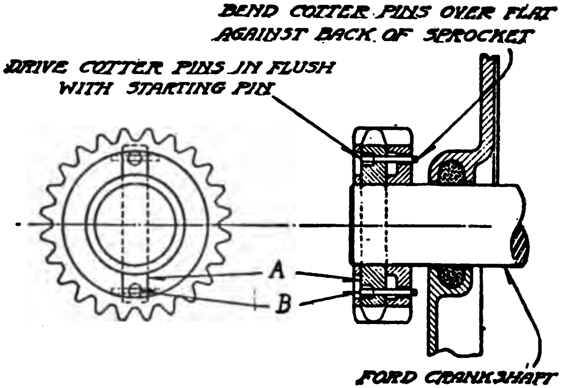

BEND COTTER PINS OVER FLAT AGAINST BACK OF SPROCKET
DRIVE COTTER PINS IN FLUSH WITH STARTING PIN
A
B
FORD CRANKSHAFT

Fig. 60—Correct assembly of cranking sprocket for Heinze-Springfield installation on Ford car

While the electrical unit is mounted loosely in place, the chain may be installed in the following manner. Place the generator shaft spacer G and the Woodruff key, 9, on the generator shaft, Fig. 58. Also place the gear and sprocket assembly H on the generator shaft, so that the large gear is on the inside toward the main bracket plate C. Place the chain I around the crankshaft sprocket J, and also place the chain around the small sprocket now on the generator shaft, taking particular care that the open side of the crankshaft sprocket is toward the front of the car. With the two sprockets and chain in this position, slide the crankshaft sprocket J and gear and sprocket assembly H into place on the crankshaft and the generator shaft respectively, taking care that the starting-pin hole in both the crankshaft and crankshaft sprocket are in alignment. Insert the starting pin A, Fig. 60, with the counter bore for the cotter pin toward the front of the car. The holes in the starting pin are to align with the holes in the rear wall of the crankshaft sprocket. When the two cotter pins, B, are in place, it is necessary that their ends be bent over against the rear face of the crankshaft sprocket while they are held up tight in the holes. Unless they are fastened in this manner, which permits no end movement, their ends are liable to be broken off and allow the starting pin to come out, which would result in very serious damage to the entire system. Tighten the chain by the fillister head cap screw, 7, in the upper chain adjusting stud D, Fig. 58, until it is reasonably tight and securely lock the unit in position by the holding stud nut, 6.

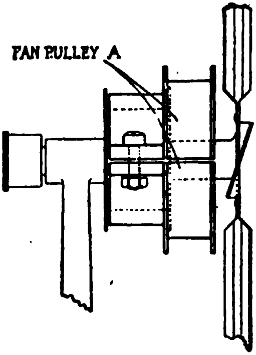


Fig. 61—Special fan pulley for Heinze-Springfield installation on Ford car

The chain cover L, Fig. 58, next is to be placed in position and should be fastened with cap screw, 11, and lock washers, 12, to the bracket plate.

Place one of the fan-belt guards M on the generator shaft, with the three projections toward the front of the car, then assemble the fan-belt pulley, N, against this guard and complete fan-belt-pulley assembly with the other fan-belt guard O, this time, however, placing the three projections toward the rear of the car. This assembly should be locked securely to the generator shaft by the use of the plain washer, 4, the castellated nut, 12. The cotter pin, 13, then must be placed through the end of this shaft to lock this nut.

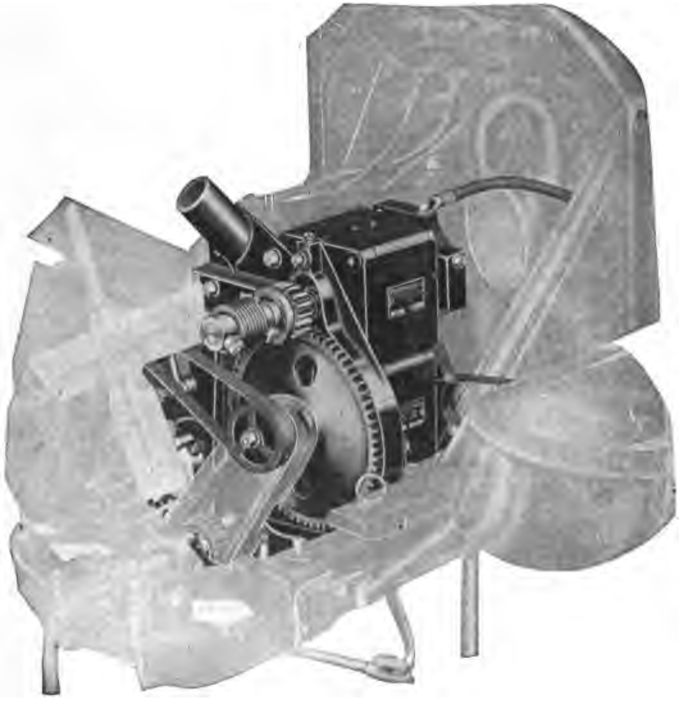
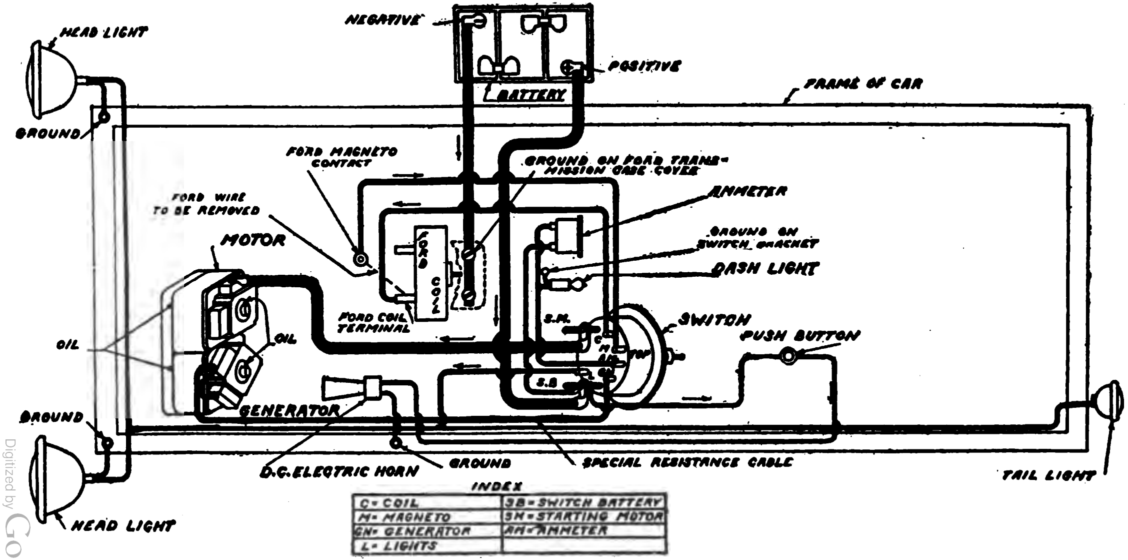


Fig. 62—View of Heinze-Springfield starting and lighting units installed on Ford car

Next install the motor rear stiffening bracket P, Fig. 58, as follows: Bolt the bracket P loosely to the cylinder head with the bolt taken out and also start the bolt, 3, Fig. 58, fastening the bracket to the motor brush head, but do not tighten. First tighten



INDEX

C = COIL	SB = SWITCH BATTERY
M = MAGNETO	SM = STARTING MOTOR
GN = GENERATOR	AM = AMMETER
L = LIGHTS	

Fig. 63—*Wiring diagram of Heinze-Springfield installation on Ford car, model* 33 *system. Generator regulation is by bucking series field* the bolt on the cylinder head, thus connecting the bracket rigidly to the Ford engine. Then tighten the bolt securing the bracket to the motor brush head. Do not be afraid to file the bracket so it will fit.

Assemble the two half pulleys, A in Fig. 61, over the Ford fan pulley and fasten them in place. With this new fan pulley the belt will run closer to the blades than before. Mount the fan in position on the main bracket plate C, Fig. 58, using the original Ford screw, and adjust the fan belt B, over the two pulleys to the proper tension.

The Bendix drive now should be installed on the motor shaft as shown in Fig. 58. Remove the drive bolt of the Bendix unit and place the latter on the starting-motor shaft; then replace the drive bolt through the hole in the end of the shaft; and secure it by the lock washer and nut, taking care to bend the small projection on the special Bendix lock washer against the side of the nut. A view of the completed installation is shown in Fig. 62.

Before reassembling the radiator, put back the hand starting crank as it was originally, and turn the engine over several times to see that everything turns free. Solder one end of the headlight ground wire to the inside face of the radiator, bringing the wire out through the holes provided for the headlight wiring, and be sure to allow sufficient wire to reach to the lamp sockets. Next replace the radiator, and turn the fan over slowly by hand to determine whether the blades interfere with anything at all. Secure the water connections and refill the radiator.

Installation of Switch and Wiring

Remove both the front and rear floor boards from the car. About an inch to the right of where the steering post goes through the dash, there is a hole in the toe board, which originally was provided for the Ford horn cable. Remove the toe board and enlarge this hole to about 1½ inches, which will be used to bring the wiring through to the switch. Remove the Ford magneto-to-coil wire, which runs from the Ford magneto to the Ford coil, and discard. Remove the present Ford switch-to-terminal wire, which runs from the Ford lamp switch to the magneto terminal on the coil, and discard. Remove all the present Ford headlight wiring, and discard.

Take the complete wiring assembly as shipped in the 13-inch

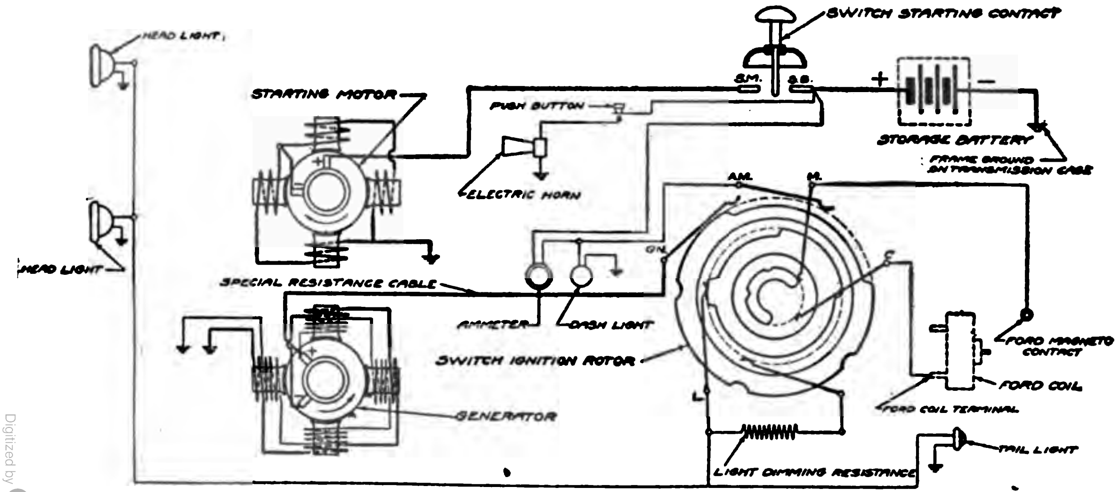


Fig. 64—Internal connections of Heinze-Springfield starting and lighting system, model 33, installed on a Ford

length of circular loom, and, with the switch mounted in the switch bracket connect the various wires, being very careful to assemble the proper terminals on the proper posts as follows, Figs. 63 and 64. Connect one large wire with terminal marked S M on the post marked S M; one large wire with terminal marked S B on the post marked S B. There remains four small wires with terminals marked C, M, L and G N which are to be placed under the heads of the spring-terminal posts bearing the corresponding letters. The spring-terminal marked A M is for the ammeter only.

By the two switch bracket clamps, fillister heads screws and lock washers, fasten the switch to the dash of the car slightly to the left of the steering post in such a position that the hole in the end of the stay rod will line up with the Ford body bolt. Remove nut from this bolt and clamp the stay rod securely in place.

These instructions for mounting the switch on the dash apply to the runabout and touring cars, and the following instructions should be followed in the case of the sedan or coupelet. By three round head blued wood screws fasten the switch to the dash of the car, slightly to the left of the steering post in such a position that the hole in the end of the stay rod will line up with the Ford body bolt. Remove the nut from this bolt and clamp the stay rod securely. The stay rod is supplied only for sedans and coupelet and must be so specified when ordering.

Extending through the 13-inch piece of circular loom are two wires, one end of each being connected to the spring terminals C and M, Fig. 63, on the back of the switch. Connect the wire from the terminal C to the magneto terminal on the Ford coil box, and connect the wire from the terminal M to the magneto contact on the fly wheel housing. These two terminals formerly were connected directly together by the magneto-to-coil wire.

On the back of the switch the spring terminal marked G N is to be connected to the upper generator brush by the special braided wire. This is a special resistance wire, and no other should be substituted. The heavy wire connected to the post marked S M on the back of the switch should have its other end connected to the upper, or positive, brush of the starting motor. The wire connected to the spring-terminal post marked L is to be connected to the headlights and tail light. This wire should be secured to the car frame at several convenient points to keep it free from oil and prevent chafing and consequent grounding of the lighting circuit. Wires are provided for grounding one side of each of the headlights and the tail light. When single contact lamps are used or if the socket is grounded, these ground wires are not required. The internal connections of the system given in Fig. 63 is shown in Fig. 64.

Battery Installation and Connection

The battery box should be installed on the right-hand running board, midway between the front and rear fenders, particular attention being taken to see that it does not interfere with the operation of the doors and at the same time offers a minimum obstruction to getting in or out of the car. In the bottom of the battery box are six holes, the four inside holes being provided for the four carriage bolts to hold the battery box on the running board and the two outside holes for the two battery hold-down rods which hold the storage battery securely in place. Six corresponding $\frac{5}{16}$-inch holes must be drilled in the running board to agree with these six holes in the bottom of the battery box. Place the two wooden pads inside the battery box and the two steel pads under the running board, and clamp them all together by the carriage bolts. Place the storage battery in the box, with the positive terminal toward the rear of the car, and fasten it in place by the hold-down rods, which are hooked over the handles and bolted on the under side of the running board. After you have done this proceed as follows.

At a point midway between the two wire holes in the battery box, pry down a part of the running-board apron, or splash board, with a large screwdriver or pinch bar, to provide sufficient space between the upper edge of the running-board apron and the bottom of the body for the 4-inch piece of circular loom through which the battery cables are to pass.

Remove the upper right-hand bolt holding the transmission case cover in place and assemble under this bolt the starting-cable clamp. From the post marked S B on the back of the switch, Fig. 63, run the positive battery cable to the battery, placing it under the starting-cable clamp, already mounted on the transmission case. Pass the cable through the circular loom placed between the running-board apron and the bottom of the body through the hole in the battery box to the positive terminal of the battery. Do not fasten this terminal to the battery until the installation is all complete and you are ready to test for shorts and grounds.

Remove the two lowest bolts from the transmission case cover, and clean the transmission case cover at this point with a piece of sandpaper or emery cloth to insure a good electrical contact at this point. Under these bolt heads assemble the brass ground strip attached to the piece of heavy cable. Run the other end of this piece of cable through the short piece of circular loom, through the hole in the battery box to the negative terminal of the storage battery and fasten it securely to the battery terminal. With all switches open touch the positive battery cable to the battery terminal, and if no spark occurs when this contact is broken, make the connection permanent. If a spark occurs locate the trouble before making a permanent connection.

Dash Switch and Horn

The dash switch is designed to control cranking, lighting and ignition. It also embodies a mechanical cutout, which opens the circuit when the engine is stopped, preventing a discharge of the battery through the generator winding. The button in the center of the switch controls the cranking motor, and the switch rotates and makes the following connections: First, ignition on, lights off; second, ignition on, lights dim; third, ignition on, lights bright; fourth, ignition on, lights, dim; fifth, all circuits open.

When the switch is in the position of lights dim, ignition off, or in the off postion, the starting button is locked, and the remainder of the switch may be locked, to prevent cranking with the ignition off and also to prevent tampering. The switch must always be in an off position when the engine is stopped, otherwise the battery will discharge through the generator winding. The Ford ignition switch should be placed in the on position and allowed to remain so at all times. The cowl light is controlled by turning the lever on the side of the light itself. The dimming of the lights is accomplished by placing a resistance in series with the lamps.

The horn equipped on the Ford car is operated by alternating current supplied by the Ford magneto. This horn, however, may be used without interfering in any way with the Heinze-Springfield equipment, but it cannot be operated by the storage battery. The user, if desired, may install a direct-current horn, which can be operated from the battery and should be connected as shown in Figs. 63 and 64.

Place the spark and throttle levers in the usual starting position, and be sure the brake lever is in the proper position so the engine is not connected mechanically to the rear axle. Depress the starting button in the center of the combination switch, and the motor should start to revolve. The rotation of the motor armature will cause the Bendix drive pinion to be carried along the threaded shaft upon which it is mounted until it engages the teeth on the large driving gear in Fig. 62. After the pinion and gear are engaged the starting motor is connected mechanically to the engine and will cause the crankshaft to rotate. If the engine does not start in a few seconds, stop the starting motor and prime the cylinders, or the choking device may be used with the starting motor in operation. Should the engine still fail to start, investigate the cause, as otherwise the battery will be exhausted needlessly. Frequent discharging of the storage battery in this way very appreciably shortens its life.

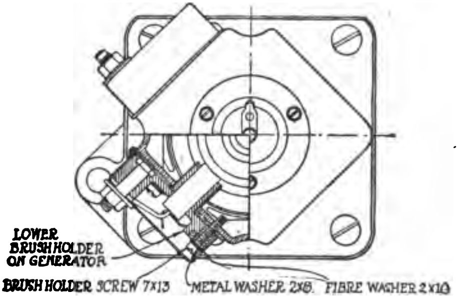


Fig. 65—Method of grounding one of the generator brushes

When the switch is thrown to any "ignition on" position the ammeter should show a discharge of 14 to 20 amperes. As the engine begins to rotate the ammeter needle will swing toward the right, indicating that the generator is operating properly.

The ball bearings on which the armature of the generator rotates should be oiled with a light non-acid oil about every 400 miles. The motor armature rotates on two white metal bearings and these should be oiled at the same time the generator bearings are oiled. Be careful in oiling the bearings not to allow any dirt to enter with the oil as this would cause the bearings to grind. The Bendix drive should never be oiled. All grease and dirt which may accumulate should be wiped off occasionally and the threads thoroughly cleaned with kerosene.

When the system first is installed the chain should be adjusted fairly tight, and the chain should be examined through the holes in the chain cover after the car has been run about 100 miles. The chain doubtless will be loose and should be tightened, and this inspection and adjustment repeated about every 300 or 400 miles. The chain may be tightened by first loosening the motor stiffening bracket at 3, Fig. 58, and also the upper and lower locking nuts, 6. By turning the fillister head cap screw, 7, which is mounted in the chain adjusting stud D, tighten the chain to the proper tension and lock the unit in place by tightening the upper and lower locking nuts and the stiffening-bracket bolt.

Refill the storage battery about once a week, especially during the summer, with distilled water. Inspect the terminals occasionally and keep them thoroughly clean from any corrosion of any kind. Baking soda and water may be used in cleaning the terminals, as it will counteract the acid. Do not allow the battery to stand in a discharged condition, especially in cold weather, as it is very likely to freeze and burst or crack the containing jars.

Adjusting Generator Output

The regulation of the cutout of model 33 generator is accomplished by a reversed or differential series field. The magnetic action of this series-field winding opposes the magnetic action of the shunt field winding and thus prevents the output increasing with increase of engine speed as rapidly as it would if this action were not present. Sometimes it is necessary to increase the output, or charging rate, and this can be done by shunting or by passing part of the current out of the series field winding and thus causing less magnetic opposition to the shunt field winding. One end of the series field is grounded and the other end is connected to the lower brush holder on the

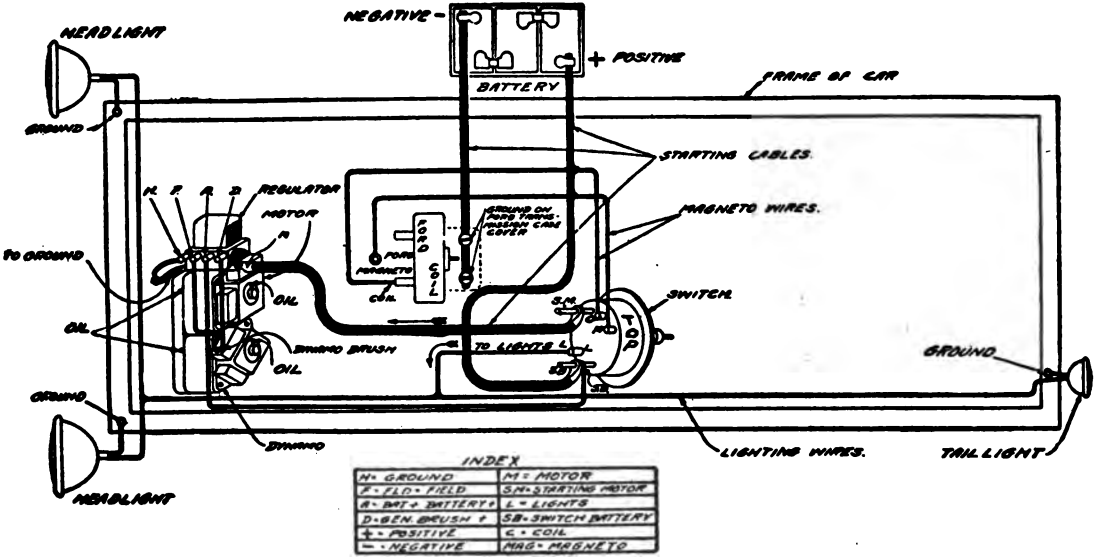


Fig. 66—Wiring diagram of Heinze-Springfield installation on Ford car. Generator equipped with electromagnetic regulation

generator, which is the bottom machine. By grounding the lower brush holder, both ends of the series field will be connected to the frame of the machine, permitting the greater part of the current to pass through the frame. The connections of the series-field winding are shown in Fig. 64.

The brush may be grounded as follows: Remove the brush cover and the brush screw, 7 x 13, Fig. 65, with the metal and fiber washers, 2 x 8, and 2 x 10, respectively. Now remove the fiber washer, 2 x 10, from the screw and replace the screw, 7 x 13, and metal washer, 2 x 8, screwing same down tightly. If all other conditions are normal the charging rate should be increased from 5 to 10 amperes.

The wiring diagram given in Fig. 66 shows a generator equipped with an electromagnetic cutout and having electromagnetic regulation. The internal connections of this system are shown in Fig. 67. If you are convinced that the trouble you are having is in the regulator its adjustment may be taken care of as follows: Connect a reliable ammeter in series with the ammeter installed on the cowl board to be used in checking. Looking at the regulator from the side on which the wires are connected to the terminals, the set of silver contact points on the near side are for regulating the value of the charging current from the generator; these points are called the regulating contacts. The other set are the cutout contacts, which close and open the circuit between the generator and the battery. First, make sure that the two sets of contacts are clean and smooth; second, determine if the regulating contacts are closed. If these contacts are not closed, bend down slightly the ear on the thin brass plate to which the flat steel spring is attached. The cutout contacts should have enough spring tension to make them stand open when the engine is not running, and the spring tension should be so adjusted that when the engine is running at a speed equivalent to 7 or 8 miles per hour the contacts will close, and the ammeter should indicate a charge. If ammeter shows discharge when contacts close, it is an indication the contacts are closing too soon and the spring tension should be increased.

The regulator contacts are adjusted by bending the ear of the thin brass supporting plate to which the flat spring is attached. To increase the current output of the generator, bend down the thin brass plate, and to decrease the current bend the

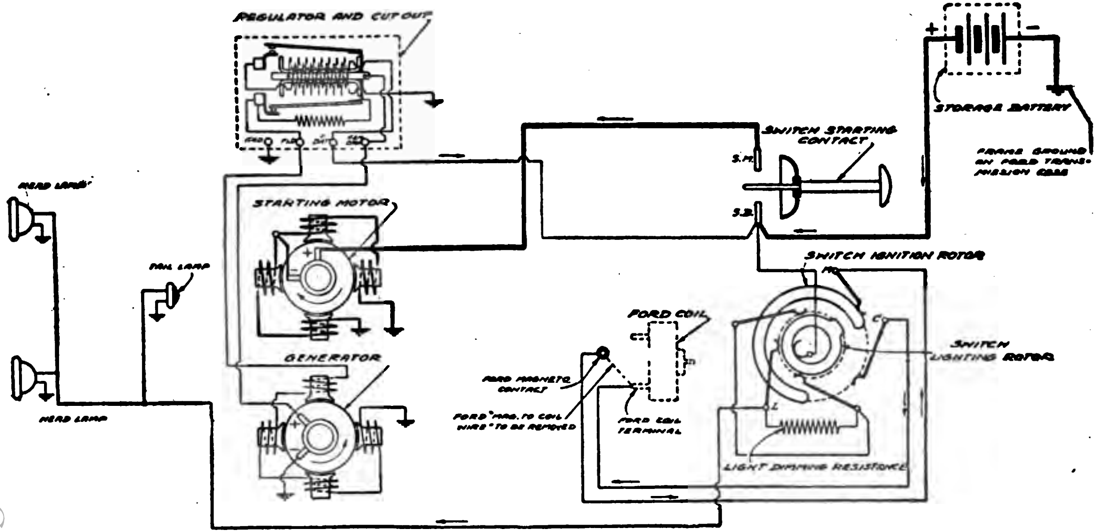


Fig. 67—Internal connections of Heinze-Springfield installation on Ford car. Generator equipped with electromagnetic regulation

thin brass plate upward. In the majority of cases, if the regulator is so adjusted that 15 amperes is the greatest current the generator will deliver, satisfactory results will be obtained. In some extreme cases the rate may have to be increased to as much as 20 amperes.

These suggestions apply to the model 33 generator with a bucking field regulation. If the type of generator having electromagnetic regulation is used, the following suggestions should be observed in addition to the above: Inspect the cutout to see that it opens and closes the circuit at the proper time so that the battery immediately starts to charge as soon as the circuit closes and the rate of discharge just before the cutout opens should not exceed two amperes. The regulator should be inspected occasionally to see that its contacts are clean and that the battery is being charged at the proper rate.

Locating Troubles

Not Cranking	Battery discharged Shorted cell Dirty or rusty Bendix Broken Bendix spring Short or open in fields Short or open in wiring Short or open in armature coils Short or open in commutator bars Short or open in connection Short or open in switch Weak springs Brushes burnt Brushes short Water or oil soaked
Cranks Slow	Battery gravity low Loose or corroded terminals Cold weather High resistance at brush contacts Starting switch making poor contact Spring tension weak Brushes not fitted to commutator Pig tails loose

Lights Dim—Battery Low		Internal leakage
		External leakage
Lights Dim—Engine Running		No water in battery
		Battery sulphated
Flickering Lights		Generator inoperative
		Loose connections in wiring
Some Lamps Bright and Some Dim		Wrong voltage of lamps
		Poor ground—wire too small
Ammeter shows no charge with engine running	Brushes	Poor ground
		Carbon dust—ground
		Binding or twisted
		Too short or twisted
		Not fitted to commutator
		Poor tension on springs
		Pig tails loose
		High resistance contacts
	Field	Open
		Shorted
		Chafed
		Loose connections
		Burnt out
		Poor ground
		Oil or water soaked
	Armature	Oil or grease on commutator
		High commutator bars
		Low commutator bars
		Shorted commutator bars
		Poor soldering of bars
		Shorted coils
		Open coils
		Armature rubbing poles
	Low amps.	Generator lead grounded
		Positive brush grounded
		Brushes not seated on commutator

CHAPTER VI

Everready System for Fords

THE Everready starting and lighting system for the Ford car is a single-unit, single-wire, 12-volt system. The combined generator and starting motor unit is mounted on a bracket attached to the front of the car, and the shaft of the unit assumes the position normally occupied by the hand crank. The mechanical connection between the shaft of the electrical unit and the crankshaft of the engine is so constructed that the armature is driven at engine speed when the unit is acting as a generator, and the armature rotates 4.3 times as fast as the crankshaft of the engine when the unit is being operated as a starting motor. The starting switch is mounted in the housing of the unit and is operated electrically by an electromagnet which in turn is energized by moving the spark lever on the steering column to a full retard position, thus closing the circuit of the electromagnet at a special switch mounted on the steering column.

The operation of the starting switch closes the series circuit through the electrical unit, opens the shunt circuit of the generator field and also pulls a pawl into engagement with the ratchet teeth arranged around the outside of the gearcase, thus causing the unit to act as a starting motor, and connected to the engine with a reduction of 4.3 to 1. As soon as the pressure is removed from the retarded spark lever, the circuit of the starting-switch electromagnet is broken, the series connection is broken, the pawl is removed from engagement and the shunt field winding is connected. When the engine reaches a speed equivalent to approximately 11.5 miles per hour on high gear, the cutout will close and connect the generator to the battery, which should immediately start to charge. The cutout is located inside the housing of the electrical unit. A separate set of brushes is provided for the generator and motor functions.

Installing Starting Bracket

Remove the Ford starting crank unit, Fig. 68. To do this reach down behind the radiator and locate the pin in the starting crank ratchet. Drive out the pin, pull out the crank and the ratchet then will be loose enough to remove. When these operations have been performed, drive out the starting crank sleeve from the front bearing as shown by operation in Fig. 68. The starting crank, the ratchet, the pin and the sleeve are to be discarded.

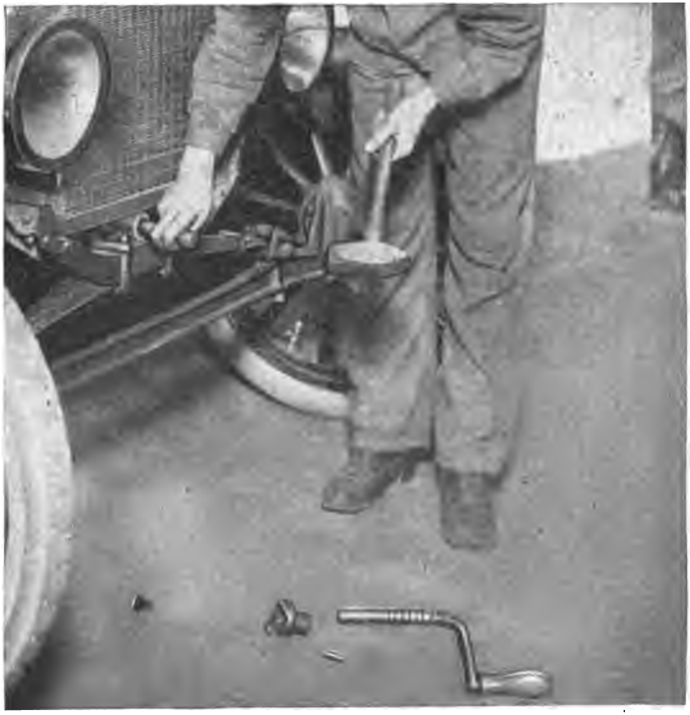


Fig. 68—*Removing starting crank and bushing in starting crank bearing*

Remove the nuts from the spring clips holding the front spring to the frame cross member. The two nuts on the front of each of the spring clips are to be discarded, but the two nuts on the rear of the spring clips will be used again.

Drive both spring clips down so that there will be sufficient space between the spring clip and lower leaf of the front spring to permit the ears of the supporting bracket brace to be inserted. Be careful not to injure the screw thread on the spring clips while driving them down.

Take the assembled supporting bracket with its brace, and loosen up the nuts on the two flat-head bolts so that the brace is free to move. Then insert first one ear of the brace between the spring clip and the lower leaf of the front spring, and after one ear is in position it will be an easy matter to slide the brace back and put the other ear in place. Then drive the spring clips back into their original position, being careful to insert the front threaded ends of the spring clips into their respective holes in the supporting bracket.

Place lock washers over the rear threaded ends of the spring clips and put back the nuts that were on originally. On the front threaded ends of the spring clips place the rectangular spring clip lock plates, after which the new spring clip clamp nuts are to be screwed on to the front threaded ends.

Tighten up all four nuts, being careful that they are drawn up uniformly. It would be best to tighten them up one turn at a time. Be sure that the spring clips tighten the supporting bracket brace uniformly. Do not let one corner of the spring clip do all the work. While tightening up the nuts, see that the front of the supporting bracket is square and perpendicular; after the nuts are thoroughly tightened, the lock plates should be turned up to prevent the front nuts from loosening. The rear nuts will be taken care of by the lock washers that were put on.

The lock plates for the front nuts should be so placed that one side lies even with the flat side of the supporting bracket. This will prevent the plate from turning. Then turn up one corner of the lock plate against the flat side of the hexagonal nut. This in turn will keep the nut from turning. If there are poor threads on any of the spring clips, it would be wise to replace such defective spring clips with new ones having perfect screw threads. Be sure that all nuts are tight.

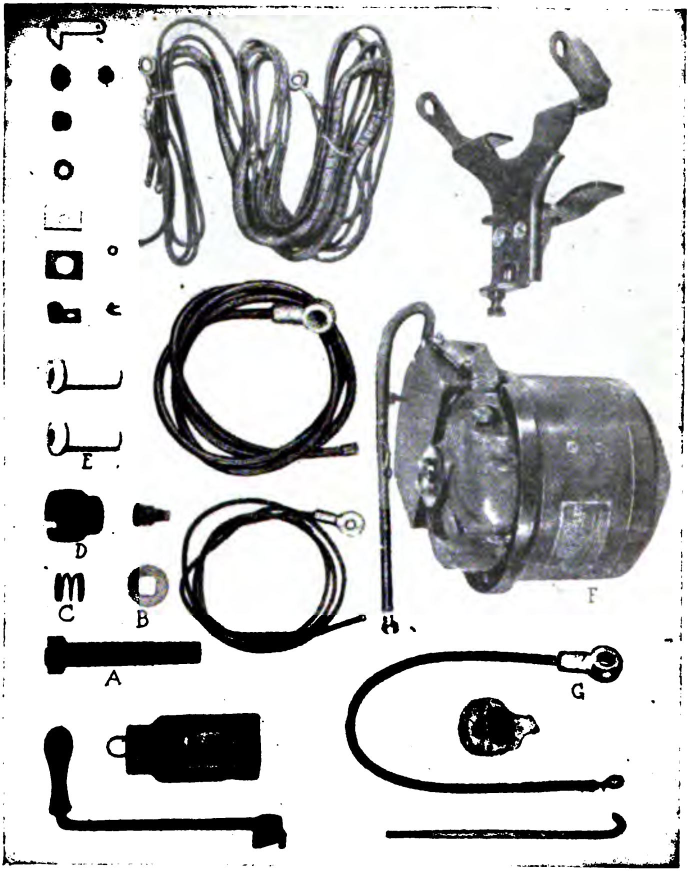


Fig. 69—Complete layout of the different parts of the Everready starting and lighting system for the Ford

After the spring clips are drawn up home, tighten up the nuts on the flat head screws. This will complete the operation of installing the supporting bracket.

Next install the coupling shaft unit composed of parts A, B, C and D, Fig. 69. Insert the coupling sleeve D in front of fan

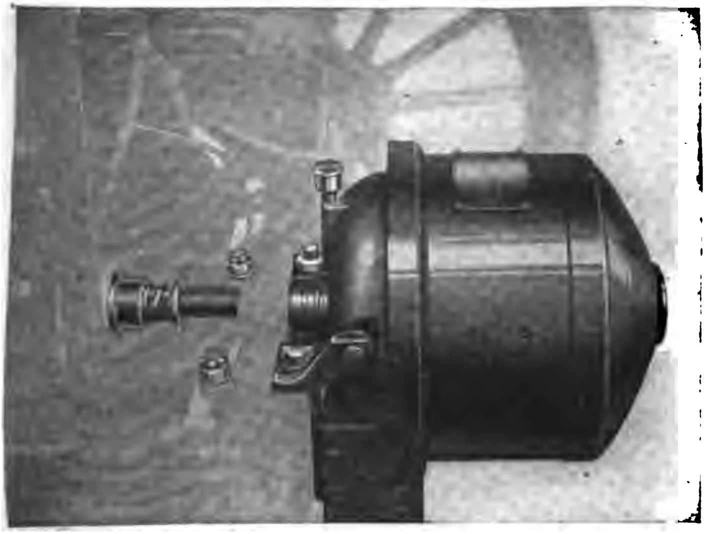


Fig. 70—Complete installation of the Everready starting and lighting unit on the Ford car

pulley and turn it until the crankshaft starting pin engages with slot in the sleeve. Next insert the coupling shaft D through the hole, from which the old hand crank and bushing were removed, until it protrudes through the rear about an inch. Then reach down behind the radiator and slip the spring retainer B over the square end of the coupling shaft. Slip coupling spring C over the protruding square end of the coupling shaft and push the shaft inward until the square end of the coupling shaft engages with the square hole in the coupling sleeve D already in place. The completed operation is shown in Fig. 70.

Installing Electrical Unit

Remove the three cap screws from the back of the electrical unit, Fig. 69. One of these screws is at either side and one at the bottom. Place the electrical unit in position so that the clutch end of the shaft, Fig. 71, will engage with the clutch end of the coupling shaft. The three holes in the electrical unit from which the screws were taken should line up with the holes in the supporting bracket shown in Fig. 71. When the electrical unit is in place, insert the two side cap screws and turn them up tight enough to hold the unit in place for the time being. Then insert the remaining screw in the same manner through the hole near the lower end of the bracket.

The next operation is to see that the coupling shaft A is lined up as near the center as possible in the hole through which it passes. Raise or lower the adjusting screw until the proper alignment is secured. When coupling shaft is centered properly, screw up the lock nut on the adjusting screw and then permanently tighten up the two side cap screws and the screw near the bottom at the back of the supporting bracket. Remove the wooden plug in the head of the electrical unit and screw the grease cup in place. Fill the cup with grease, screw it down once and refill.

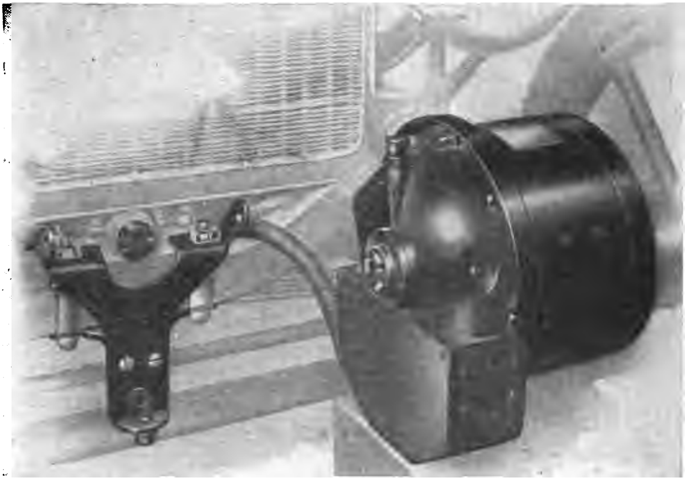


Fig. 71—Method of mounting the Everreaay electrical unit on the Ford car

Installing Storage Battery

The sheet metal battery box should be placed on the right-hand running-board, having the side with the lock facing outward.

The box is to be placed as near as possible to the body of the car, being centrally located between the fore and rear doors, so that both doors will clear the box when the cover is raised. When properly placed, indicate holes to be drilled in the running board by spotting through the holes in the battery box with a piece of chalk. Then remove the battery box and drill the holes in accordance with the chalk marks, but make sure that these holes are the same size as the holes in the battery box itself. Replace the battery box on the running board and insert the two unglazed porcelain insulators. Place the battery in the battery box, making sure that the terminals are toward the body of the car. Also make sure that the battery is located centrally in the box, so that it does not touch the porcelain insulators. Insert the threaded ends of the hold-down hooks through the holes in the battery box and through the drilled holes in the running board and see that the hooks engage in the recess provided for this purpose in the sides of the battery handles. Then from underneath the running-board place washers over the threaded ends of the hold-down hooks and tighten up with nuts. The manufacturers recommend placing a small hardwood block over the threaded end of the hold-down hooks underneath the running-board before applying the washers and nuts.

Installing Wiring to the Unit

The negative cable E, Fig. 69, is to be connected with the negative battery terminal and the negative cable protruding from the electrical unit F. To accomplish this proceed as follows: See that the lead plugs on the cable and the lead terminals on the storage battery are cleaned properly and coated with a thin film of vaseline. When this is done, insert the small end of the cable through the forward unglazed insulator, run the cable up over the rod, connecting the two running boards and from there follow the frame underneath the mud guard as shown in Fig. 72. This cable is held in place by two clips provided for this purpose. The clips are to be fastened underneath the chassis side member by two nuts located as indicated in Fig. 72. This lug end of the cable now is to be placed over the negative terminal post of the battery.

The next operation is to connect cable E with the short cable I. To do this pass the cable up over the front cross mem-

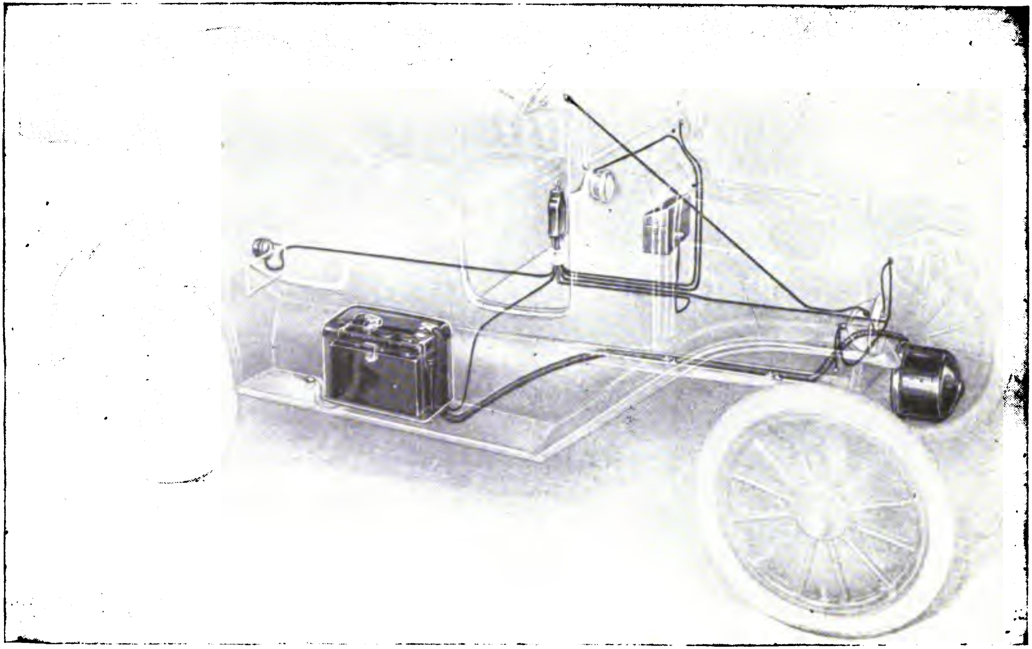


Fig. 72—Phantom view of wiring installation of Everready system for the Ford car

ber as shown in Fig. 71, over the strut until it meets the longer cable. Fasten both cables together by tightening up the coupling nut and then carefully tape the joint to prevent the possibility of a short-circuit.

Installing Master Switch

The master switch is to be installed on the steering column as near to the steering wheel as possible, Fig. 73. In case the horn push button interferes, lower its position as in the figure. The master switch proper is installed by fastening the clamp around the steering column and screwing it up tight with nut and bolt provided for this purpose. Next run the wire down the under side of the steering column, and pass it through the hole in the floor board. Continue the wire down the under side of the steering column to the left-hand side of the chassis, run it forward along the chassis and make connection by the screw and nut provided to the small terminal protruding from the side of the negative cable. After making the connection, tape carefully to prevent short-circuit.

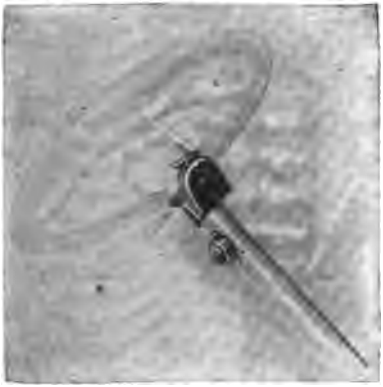


Fig. 73—Location of the master switch on steering column

Lighting Switch and Wiring

Install the lighting switch on the heel board in position as shown in Fig. 72. Drill a hole in the floor board large enough for the insertion of the glazed porcelain insulator. This hole should be drilled between the inner side of the body and the outside of the side member of the chassis and as far back as possible, allowing sufficient clearance for the wires to enter the switch. Insert the glazed porcelain insulator through the drilled hole, having the head above the floor board. Next drill two holes in the vertical board so that the switch may be attached centrally above the porcelain insulator. The switch also must be placed high enough up on the vertical board to permit of easy access for wires.

In case the car has a bead running across the bottom of the vertical board which fits the groove in the back of the switch, make sure that the use of this bead as a guide does not locate the switch too low. After the holes have been drilled in the vertical board take off the outside nut and washer from both attaching screws in the back of the switch. Do not remove the remaining lock nut. Now insert the screws through the holes in the vertical board, having the switch handle pointing upward. Lift up the seat, which will permit you to reach down and replace the washers and nuts on attaching screws. When the switch is firmly in place, remove the cover to make the wire connections.

Select the small wire with lead terminal and run the small end down through the forward unglazed porcelain in the battery box, which holds the large negative cable. Place the lead terminal of this small wire over the battery negative terminal and on top of the negative cable lug, after which fasten it in position with the screw previously removed from the battery terminal. Now run the small wire up along the chassis and draw it across to the left-hand side of the car where this wire, together with the taped group of lighting wires, is to be pushed up through the glazed porcelain insulator in the floor board preparatory to being attached to the various terminals in the switch.

Fasten the terminal of the wire coming from the battery under the head of the screw of the terminal post in the upper row, which is connected to the wide curved brass connecting strip.

The next operation is to connect the terminals of the four wires which lead to the headlights, sidelights, taillight and coil box. It will be noted that each of these wire leads has a letter, T, I, H and S respectively. The lower row of terminals in the switch box have corresponding letters to guide you in making the correct connections.

The first wire protruding singly from the taped group is to be connected with the taillight. To accomplish this, run the wire along the left side of the chassis to the taillight as shown in Fig. 72. If the taillight has a two-wire socket, the extra wire coming from the socket should be grounded. The remaining wires should be brought forward along the side member of the chassis and fastened permanently.

The long wire, having double branch wires with large loop ends, is for connection to the headlights. Pass this wire along the left side of the chassis, Fig. 72. The first pair of branch wires are to be connected to the socket at the back of the left headlight and the loop is to be grounded under the nut which holds down the left side of the radiator. The second pair of branch wires is to be attached to the right headlight socket in the same manner as with the left headlight.

The shortest remaining wire is for the ignition connection and should be attached to the ignition post of the coil box, which is located above the rear spark plug. In making this connection care should be taken to keep the ignition wire as far away as possible from the high-tension wires leading to the spark plugs.

Two wires without terminals remain. The shorter of the two is to be connected to the left sidelight. To do this push the wire up through the crack between the dash board and the floor board, run the wire up inside of the body and out through the small hole, which should be drilled through the metal cowl near the rear of the side lamp. The other wire is to be attached to the right sidelight and should be brought up through the same crack used for the other wire and passed across the inside of the car to the right side in whatever manner is most convenient. In the event of the sockets in the sidelights being two-wire construction, the second wire from each lamp must be grounded to some metallic connection on the chassis frame.

In case the car is not equipped with electric sidelights tape the ends of the two wires furnished for this purpose and secure them underneath the chassis where they will not be in the way. Proper staples are furnished for attaching the wires to the dash board or wooden body sill of the car.

After all connections have been made, battery ground cable G, Fig. 69, is to be connected to the battery and ground under the runningboard as in Fig. 72. To do this, pass the small end of the cable through the rear porcelain insulator in the battery box and bring the cable under the runningboard to the bolt nearest the car body on the runningboard supporting bracket and permanently fasten it in position.

To complete the wiring system, attach the battery ground-cable lug to the positive post of the battery and secure with the cap screw provided for that purpose. Before making this connection thoroughly clean the connecting post and the cable lug and then apply a thin coat of vaseline.

Fuses

Fuses are provided inside the lighting switch, connecting corresponding terminals in the upper and the lower rows of terminals. There is a separate fuse for each circuit, ignition included.

In case of the fuse melting due to short-circuit on any part of the lighting circuit or primary ignition circuit, another piece of 10-ampere full wire should be inserted.

Before Starting

Before starting see that the spark lever on the steering wheel is touching the contact arm on the master switch. When this is done make sure that the commutator arm on the Ford timer is in a perpendicular position. Should this commutator arm not be as described bend the commutator connecting rod until the arm is perpendicular as directed. This is the last operation and one which must be performed to insure satisfactory retard of the spark for starting. It is advisable before attempting to use the electrical unit to check over the entire installation to make sure that all connections have been made properly.

Extra Battery Connection

The regular battery provided with this system is supplied with an extra 6-volt neutral wire, which must not be used in connection with the lighting installation as described, which provides for the use of 12-volt lamps. The 6-volt neutral wire is provided for the convenience of the car owner for the possible installation of 6-volt electric horns or other 6-volt accessories. The method of installation described provides 12-volt battery ignition for starting purposes, and under no circumstances should the 6-volt neutral battery wire be connected to the battery post on the coil box.

Lighting Operation

When the lighting switch handle is pushed down all the way, the lamps are disconnected; when raised half way, sidelights and taillight are connected, and when raised all the way, headlight and taillight are connected.

Starting Operation

To operate the electrical unit as a motor throw the coil box ignition switch to the battery side and press the spark lever into a position of full retard, thereby pushing the master switch contact arm as far back as it will go. This makes contact in the master switch, and if all connections have been made properly the starting motor will turn over the engine.

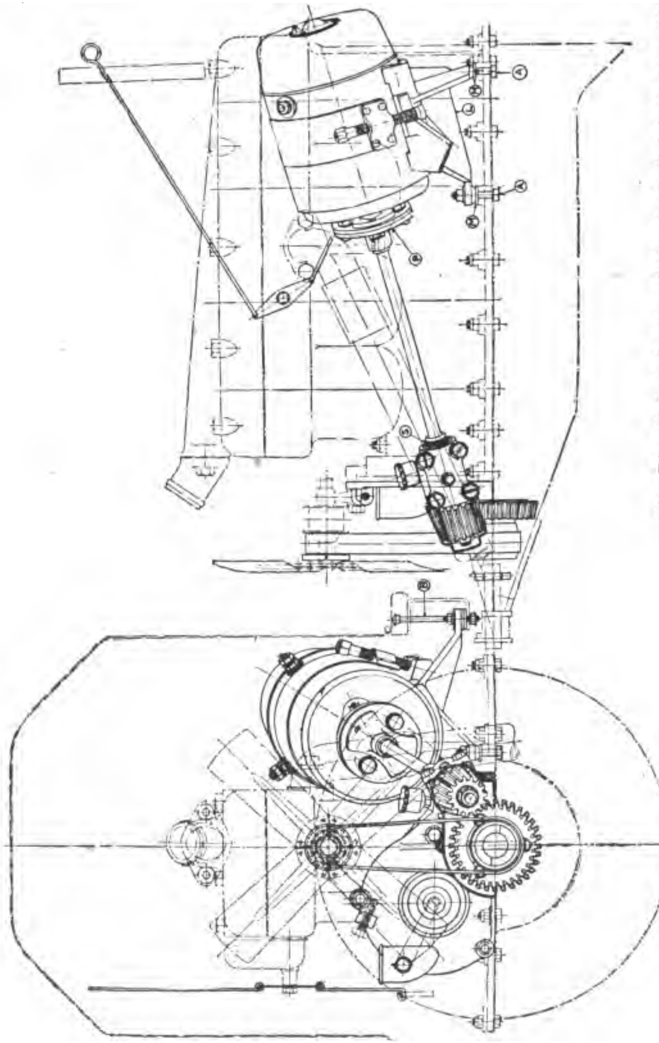


Fig. 74—End and side views of shaft-driven type of Genemotor for Ford cars

CHAPTER VII

Genemotor for Fords

THE shaft-driven type of Genemotor for the Ford car is a single-unit, two-wire, 12-volt equipment. The electrical unit is mounted on the left-hand side of the engine on a special bracket

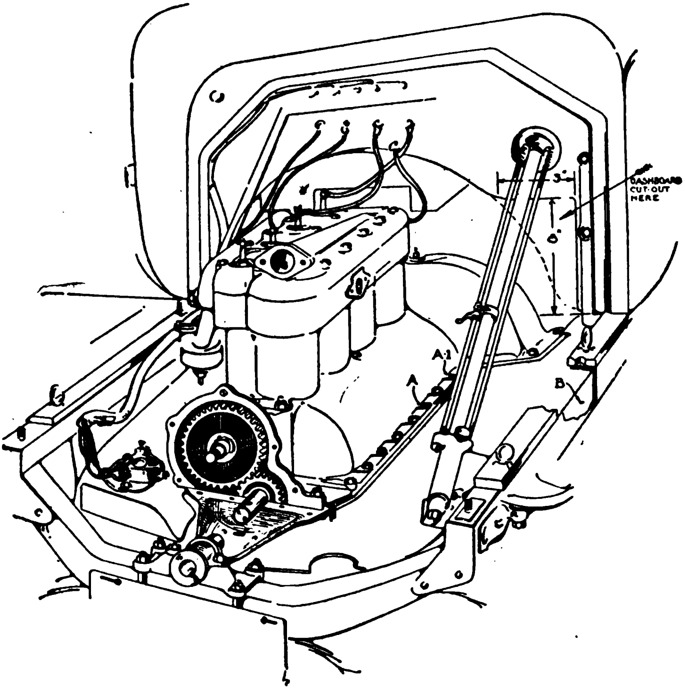


Fig. 75—*Ford engine ready for mounting shaft-driven type of Genemotor* attached to the engine base and is driven by a special shaft and gear.

Preparation of Engine

Before dismantling the engine be sure that it is in good condition, running smoothly and that the carbureter is properly adjusted. Remove the radiator with all the water-pipe and elbow connections, starting crank and ratchet clutch, fan bracket complete with the fan and belt, fan drive pulley on the crankshaft, timer, or commutator complete, timing gear cover—leave paper gasket in place—engine bolts A and sill bolt B, Fig. 74. Clean and wipe the engine carefully to insure perfect seating of all parts.

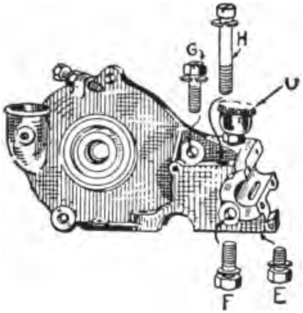


Fig. 76—Timing gear, or front cylinder, cover assembly

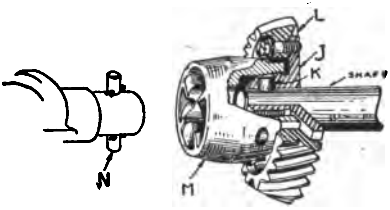


Fig. 77 — Method of mounting split hub on the crankshaft

Cut out the dashboard as in Fig. 75. Remove the felt packing rings around the crankshaft and camshaft from the old timing gear cover, or housing plate, and place them in the new timing gear cover, which sometimes is called the cylinder front cover. Re-assemble the new cylinder front cover, oil the engine, placing bolts E, F, G and H, Fig. 76, with lock washers, in holes indicated. Leave these bolts slightly loose.

Throw the hand brake lever into the middle position and push the crankshaft back as far as it will go. Assemble the split hub J, Fig. 77, on the crankshaft, inserting hub pin through the set of holes in the hub which gives not less than $\frac{1}{32}$ inch and not over $\frac{3}{32}$ inch clearance back of the hub flange and cylinder front cover.

Drive the hub pin K, Fig. 77, in crankshaft, being careful that the ends are an equal distance below the surface of the threaded portion of the hub. Chisel off part of the rivet heads XX in the nose pan of the engine and assemble the gear ring L as in Fig. 78. In some cases it may be found necessary to bend out the sides of the nose pan slightly by a monkey wrench, as in Fig. 78, to obtain the necessary clearance for the gear ring. This clearance should not be less than $\frac{1}{64}$ inch at any point. The recess in the back of the gear ring will permit the insertion of the gear ring past the front of the crankshaft. The gear ring, after being placed in position, should be fastened with the three screws and lock washers provided for this purpose.

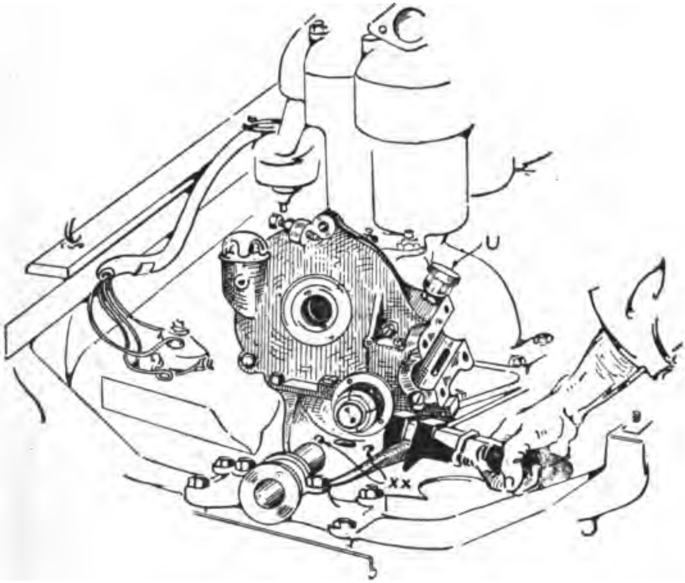


Fig. 78—Bending the nose pan to provide the clearance necessary for the gear ring

Throw the hand brake lever to the extreme forward position to lock the engine, and screw the hub nut M, Fig. 77, on the hub, tightening same with a 3/8-inch steel rod inserted in the holes provided in the hub.

Replace the cranking handle less the Ford ratchet clutch, using in place of the latter the ratchet pin supplied with the equipment

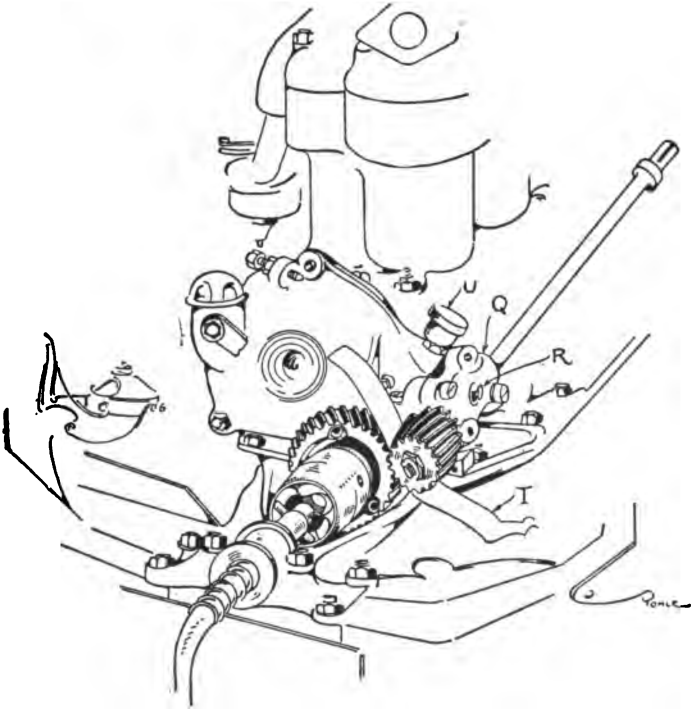


Fig. 79—Adjusting the position of the driving pinion

and retaining same in place with two cotter pins N as in Fig. 77.

Remove the leather coupling P, Fig. 74, from the end of pinion shaft. Unscrew the bearing housing cap Q, Fig. 79, from the cylinder front cover, and place the bearing lining, with the pinion shaft, in place. The coupling is keyed to both the armature and driveshaft and should be removed complete by driving it off of either shaft rather than separating the leather from the flanges. Be sure that screw R, Fig. 79, in the bearing cap enters the hole in the bearing lining before replacing the cap and that the shaft does not strike the base of the engine casting which would cause the shaft to become sprung. If necessary file away the corner of the engine base so that the shaft has a clearance of at least $\frac{1}{32}$ inch.

Adjustment of Gears

The steel gear at all times must run on the Fabroil teeth of the pinion and not on its steel shrouds. This may be accomplished by rearranging the steel spacers S, Fig. 74, on the pinion shaft, placing more or less forward or back of the lining as may be necessary. In no case should any washers be left out. Throw the hand brake lever to the middle position and turn the engine over with the cranking handle, feeding in between the gears the strip of paper T, Fig. 79, supplied for this purpose. Lightly tap the cylinder cover over to the left as far as necessary to mesh

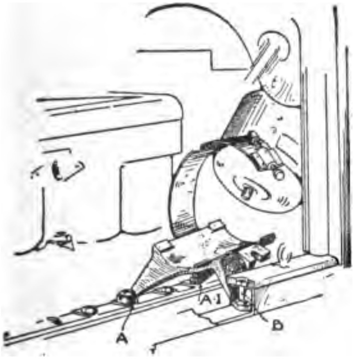


Fig. 80—*Assembly of the mounting cradle for the shaft-driven electrical unit*

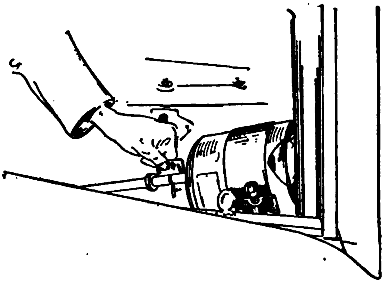


Fig. 81—*Checking the alignment of the driveshaft and the shaft of the electrical unit* the gears tightly, and then tighten the retaining bolt in the cover. Turn the engine over again until the paper is fed out. The paper should be evenly marked but not cut. Under no circumstances place any shim between the bearing lining and its supporting housing.

Genemotor Mounting and Alignment

Assemble the cradle for the Genemotor in place as in Fig. 80. Place a 1/8-inch spacing washer under the leg nearest to transmission cover and insert special bolt A-1 with lock washer from the under side of the car, but have it slightly loose. Put the front leg bolt A and new sill bolt B with the lock washers in place, but do not tighten them up. Insert the Genemotor from the rear side of the dash through the opening previously cut for this purpose, sliding it into its cradle, and then clamp it in place with the steel strap, leaving about 3/8 inch space, Fig. 81, between the motor shaft and the pinion shaft. The flat on the frame of the Genemotor should be parallel to the iron dash support.

Raise the front leg and the sill leg of the cradle by suitable thickness of the spacing washers supplied, until the ends of the shafts are in line, utilizing the clearance in the bolt holes to obtain sidewise adjustment. The ends of the shafts must be lined up accurately to at least 1/64 inch or the bearings will ovearheat and may be destroyed. The alignment of the two shafts may be checked as in Fig. 81. When the alignment is satisfactory tighten up all the bolts holding the cradle, setting up the lower nut on the sill bolt first, and then recheck line-up. If necessary, readjust.

Remove the bearing cap and pinion shaft. Assemble the leather coupling on the pinion shaft and then assemble the other end of the coupling on the generator shaft. Both should be a good tight fit. Fill the recess in the bearing lining and the bearing with a good grade of non-acid grease. Replace the bearing lining and the shaft in the housing and fasten the bearing cap in place.

Fill and fully compress the grease cup U, Fig. 79, at least twice to make sure that the grooves and sprockets are filled. Thoroughly grease the gears and assemble the gear guard with its two screws and lock washers.

The timer, or commutator, now may be replaced. Fit the two-piece fan pulley around the neck of the Ford fan pulley and fasten it with the screws and lock washers provided. Reassemble the fan and the bracket complete to the cylinder front cover, using the new 1-inch belt, which is driven from the pulley, and the gear hub nut M shown in Fig. 77. Replace the radiator and water connections, using the special bolt for the water connection elbow nearest the generator. Replace the timer connecting rod, bending same to pass over instead of under the water connection. The throttle rod must be turned upside down and assembled with the cotter pins toward the dash to clear the coupling. Attach the primer rod and lever as in Fig. 82, using part of Ford timer rod originally coming through the radiator.

Mount the starting switch and cutout on the under side of the floor board as in Fig. 83. Mount the lighting switch on the steering column as in Fig. 84. The battery box should be mounted on the right-hand running-board. The holes that must be drilled in the running-board and splash plate to accommodate the battery leads and mounting bolts for three different models are shown in Fig. 85.

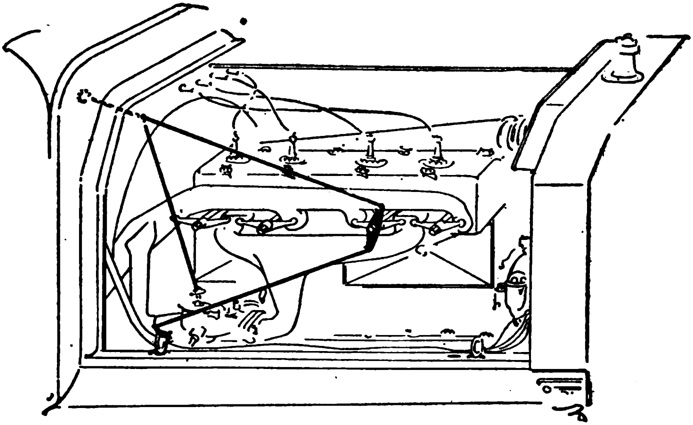


Fig. 82—*Method of attaching the primer rod and lever*

The headlights and taillights may be wired up with the leads supplied, which are tagged to correspond to the diagram given in Fig. 86. Connect the electrical unit to the switch and cutout, as in Fig. 86, placing on each battery cable a piece of the circular loom supplied at the point where the cables pass through the slot cut in the splash plate. This circular loom should be held in place by friction tape at each end. Place the battery in the box with the wooden cleats beneath it, and clamp it to the running-board with the battery clamps through the holes in the bottom of the box and the running-board. Connect the negative lead to the battery terminal marked —, and then touch the positive lead to the battery terminal marked+. If no spark is observed when this contact is broken, with all switches open, connect the terminal permanently. If a spark is observed the system is in trouble and the difficulty should be remedied before a permanent connection is made. Make sure the engine turns freely before trying the starting motor.

Operation and Precautions

The grease cup in the front bearing should be kept full of grease and compresed two or three turns every 200 miles. The gear teeth should be greased about every 500 miles by inserting grease through the hole in the rear guard. The lamps recommended for use with the system are 12- and 14-volt, 15-candlepower Mazda or 24-candlepower nitrogen and 12- and 14-volt, 4-candlepower Mazda for the tail light. Additional precautions that must be observed are given under the heading Operating and Precautions for the chain-driven type.

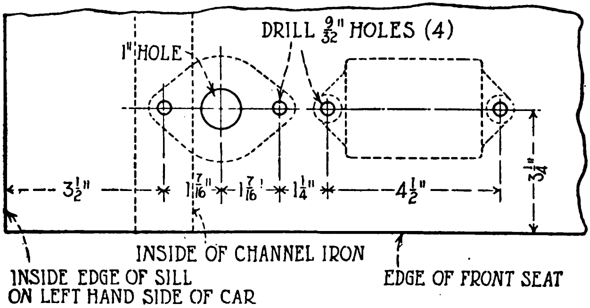


Fig. 83—*Layout for holes used in mounting starting switch and cutout on the under side of the heel board*

Installing Ammeter

An ammeter is not supplied regularly with the system as the makers do not deem it necessary since the generator is provided with the inherent type of regulation of the third-brush type, so that as long as the commutator, brushes, battery connections, etc., are kept in good condition charging of the battery is assured. If the owner considers it advisable to install an ammeter to check the operation of the system, the instrument readily may be added by removing the jumper wire from the starting switch to the cutout and connecting the ammeter leads between these two points as in Fig. 87.

Chain-Driven Genemotor

The chain-driven type of Genemotor for the Ford car as put out in 1917 was of the single-unit, two-wire, 12-volt type. The unit is mounted on the left-hand side of the engine on a special bracket attached to the engine base and driven by a silent chain. The generator output is regulated by the third-brush method.

Installation of Electrical Unit

First clean the engine thoroughly to insure proper seating of the supporting bracket. Also remove any high spots or fins on the castings that may in any way interfere. Mount the supporting bracket on the engine, inserting first the bolts through the base, then the water-flange bolts, with the elbows. Place the gaskets on each side of the bracket. Use the plain washers between the engine case and the foot of the supporting bracket to insure proper support of the bracket and alignment of the holes with water-pipe connections, and bolt the bracket in position temporarily. Chisel off part of the two rear rivet heads in the nose pan of the engine and bend out the edge of the nose, to provide clearance for the driving chain. There should be at least ⅛ inch clearance at all points around the sprocket after the chain is in place. Replace the starting crank and turn the engine over slowly to feed the chain on to the engine sprocket, and connect the ends of the chain together. Carefully observe the arrow on

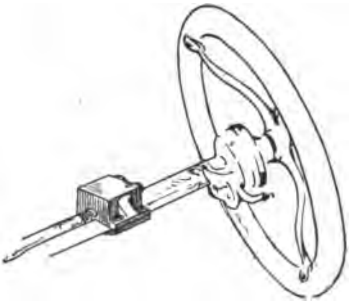


Fig. 84—Lighting switch mounted on the steering post

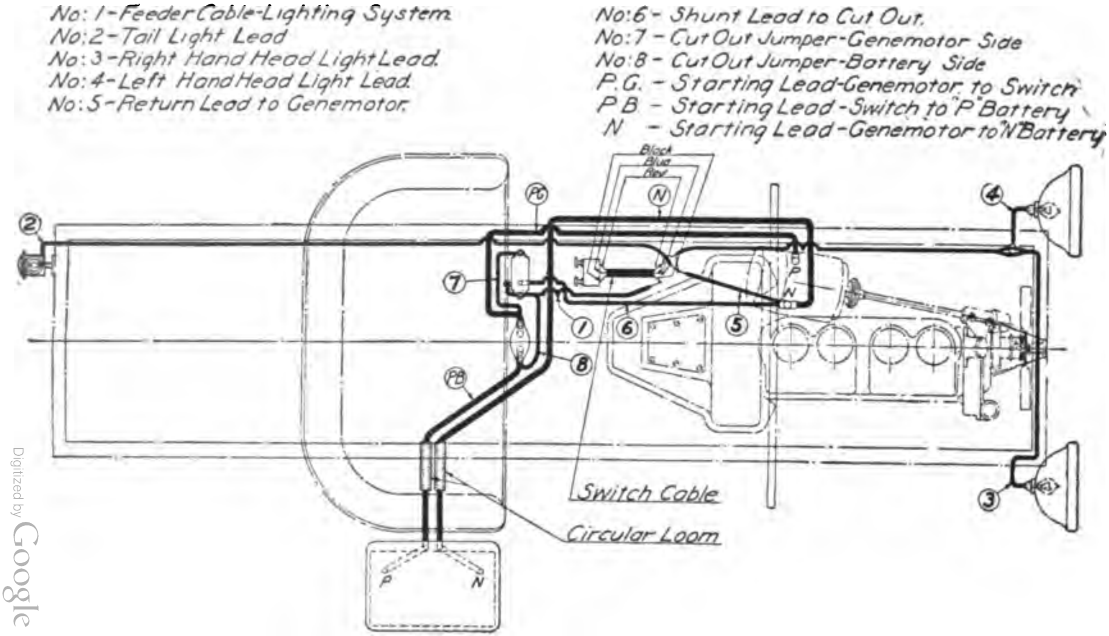

No: 1-Feeder Cable-Lighting System
No: 2-Tail Light Lead
No: 3-Right Hand Head Light Lead
No: 4-Left Hand Head Light Lead
No: 5-Return Lead to Genemotor
No: 6- Shunt Lead to Cut Out
No: 7 - Cut Out Jumper-Genemotor Side
No: 8 - Cut Out Jumper-Battery Side
P.G. - Starting Lead-Genemotor to Switch
P.B - Starting Lead-Switch to "P" Battery
N - Starting Lead-Genemotor to "N" Battery
Black
Blue
Red
N
PG
PB
P
N
1
2
3
4
5
6
7
8
Switch Cable
Circular Loom
P
N

Fig. 86—Wiring diagram of improved shaft-drive Genemotor

the side of the chain which indicates the direction in which it must travel.

Remove the generator pulley as a unit with the internal spring to prevent possibility of changing the spring adjustment. Care should be taken that the slot in the spring support, into which the forks of the pinion assemble, clears the key. These can be brought into line by holding the pinion and turning the fan pulley in a counter-clockwise direction.

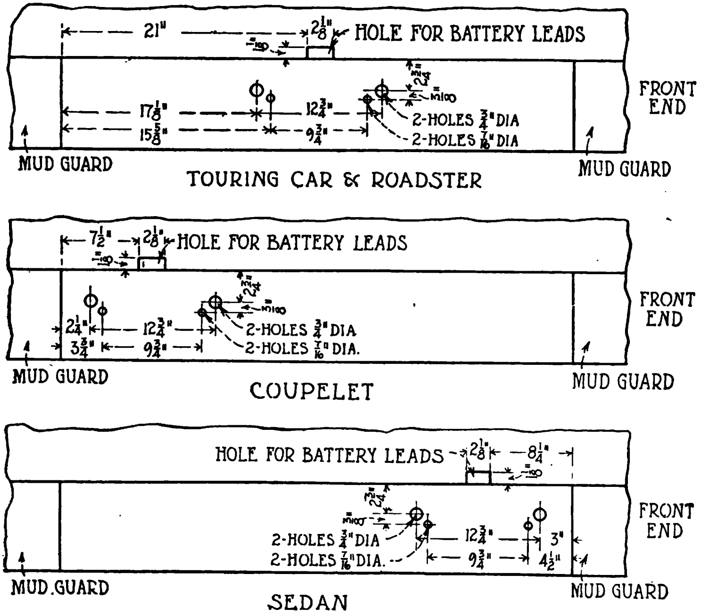


Fig. 85—Layout of right-hand runningboard for mounting battery box on the different models of the Ford car

Mount the Genemotor in place and fasten the clamping strap loosely. Apply a straight edge, Fig. 88, and align the sprockets accurately, making sure that the Genemotor shaft is parallel to the crankshaft and that the pinion on the Genemotor shaft, with bushing, is pressed against the ball bearing. In adjusting the chain allow a small amount of slack. Something like ⅜ inch deflection under finger pressure should be allowed. Adjustment of the chain is made by the two set screws. When such an adjustment is made be sure that the starting switch is in an upright position on top of the unit, and then tighten the clamping strap. The chain should be greased thoroughly and the chain guard fastened in position. Replace the pulley, with spring, locking it with the pinion as when received.

The special clamp pulley now should be assembled on the regular fan pulley, reducing the diameter of the flanges of the latter if necessary by filing. Replace the fan and the bracket on the engine, and if the fan blades do not clear the pulley on the end of the Genemotor shaft, twist them slightly with a wrench and bend out the tips of the blades. Put on the regular fan belt but do not adjust it too tightly. Replace the timer rod, making sure it clears the chain by bending the rod if necessary.

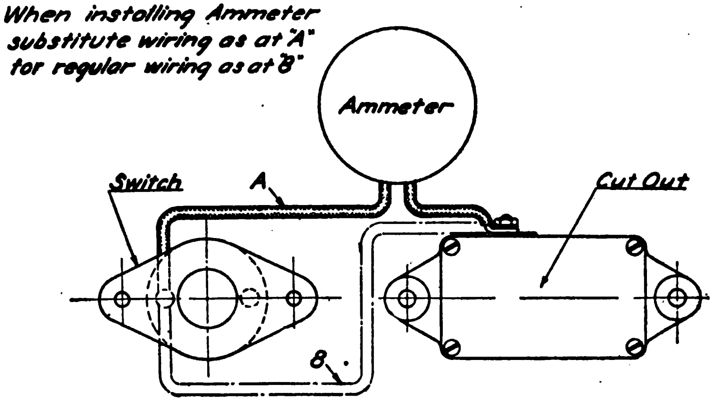

When installing Ammeter substitute wiring as at "A" for regular wiring as at "B"
Ammeter
Switch
A
Cut Out
B

Fig. 87—*Wiring diagram showing connections of ammeter in the circuit*

The dashboard is to be drilled for the lighting switch on the right-hand side as viewed from the seat, directly under the gasoline supply adjustment for the carbureter, and on the left-hand side close to the coil box for the starting switch rod. Mount the primer lever by placing the special washer under the second manifold stud nut, passing the original rod to the dash board.

Chain-Drive Genemotor Wiring

All the various leads are marked for their proper connection, and by reference to the wiring diagram in Fig. 89 the various connections may be followed readily.

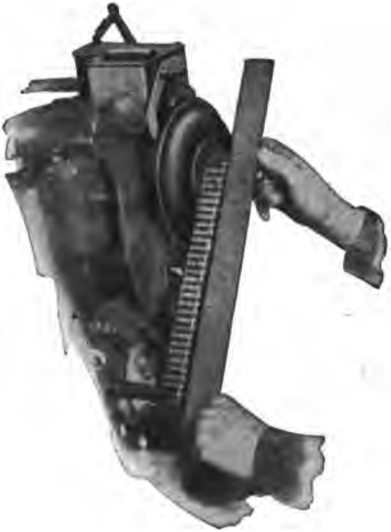


Fig. 88—*Method of checking adjustment of the driving chain*

The battery box is to be held down firmly to the running-board by two special clamps. These clamps fasten to the handles of the battery box and pass down through the holes in the running-board.

The motor leads shipped with the outfit are to run diagonally across the transmission case of the engine from the Genemotor to the battery. These leads are to be secured in place by the steel clip furnished with the outfit. This clip is to be fastened under the right-hand screw next to the dash, holding the transmission cover in place. After the wiring is complete connect the negative battery lead to the battery permanently. Before connecting the positive lead touch it to the battery terminal with all switches off and observe if there is any spark on breaking the connection. If no spark occurs a permanent connection may be made, while if a spark does occur the difficulty should be corrected before making a permanent connection.

Turn the engine over by hand to see that everything is clear. If found O. K. the machine is ready for test. On the 1915 and subsequent models, on which the headlights are electric and operated from the magneto, it will be necessary to discard the wiring and switch connections and do away with the ground connection of the left-hand lamp, as the Genemotor system is of the two-wire type throughout and all the lamps are fed from the storage battery through a lighting switch provided with the system.

In the improved type of the chain-drive Genemotor the fan is driven directly from a special pulley mounted on the crankshaft at the same time the driving gear is mounted, Fig. 90. The starting switch and cutout instead of being mounted on top of the Genemotor and in combination with each other, are made to be mounted on the under side of the floor board and directly in front of the heel board. The proper location of the holes and their proper size for mounting the starting switch and cutout are given in Fig. 83. The lighting switch is made to be mounted on the steering column. The location and size of the holes that must be drilled in the running-board to accommodate

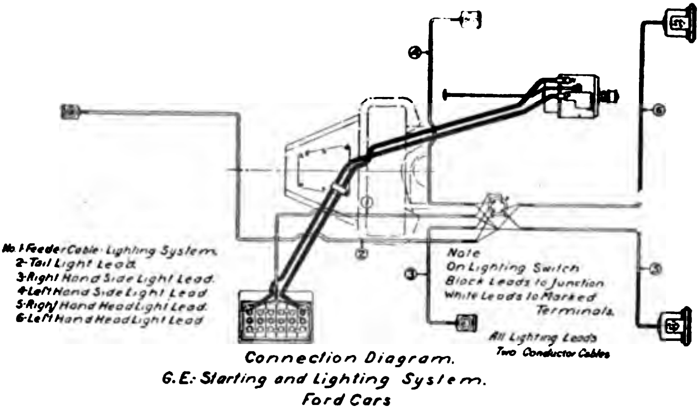

No. 1 Feeder Cable · Lighting System.
2-Tail Light Lead.
3-Right Hand Side Light Lead.
4-Left Hand Side Light Lead
5-Right Hand Head Light Lead.
6-Left Hand Head Light Lead
Note
On Lighting Switch
Black Leads to Junction
White Leads to Marked
Terminals.
All Lighting Leads
Two Conductor Cables
Connection Diagram.
G.E. Starting and Lighting System.
Ford Cars
1
2
3
4
5
6

Fig. 89—Wiring diagram of the chain-drive Genemotor system for the Ford car

the battery cables and mounting clamps are given in Fig. 91. A complete wiring diagram of the system is shown in Fig. 86.

The Genemotor is a single-unit outfit, that is, the same machine performs the functions of both generator and starting motor. Regulation of the output is accomplished by the third-brush method.

Lubricate the ball bearings at the end of the Genemotor with a few drops of non-acid oil every 1000 miles. Grease the chain every 500 miles and keep taking up the slack as the chain stretches and the links seat themselves in the sprockets. Do not use any lubricants containing any solid matter in greasing the chain, as this will produce excessive wear. If the chain becomes gummy, it should be cleaned by brushing with kerosene and then lubricated by rubbing a good quality of cup grease on the inside surface of the chain.

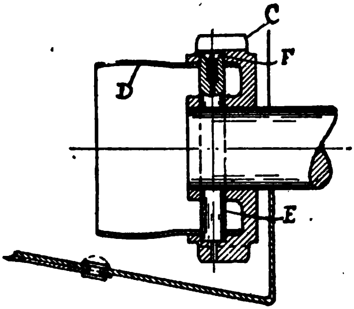


Fig. 90—*Method of mounting driving gear and fan pulley on crankshaft*

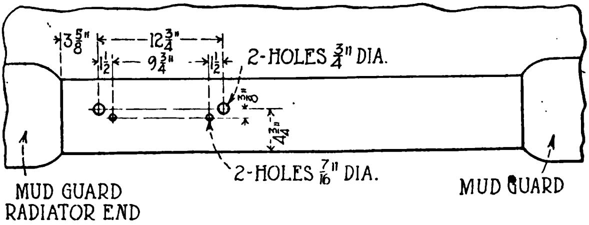


Fig. 91—*Location of holes on left-hand running board for mounting storage box with improved chain-drive Genemotor*

If the commutator becomes dirty clean it thoroughly, and if it should become roughened obtain a small piece of fine sandpaper and smooth it down. The sandpaper should not be coarser than 00.

Under no conditions try to operate the Genemotor with the battery removed unless the two generator terminals first are connected together with a copper wire or cable, otherwise the Genemotor will over-heat and perhaps seriously damage the windings. The lights cannot be used with the battery removed. Never try to operate the Genemotor with the small regulating brush

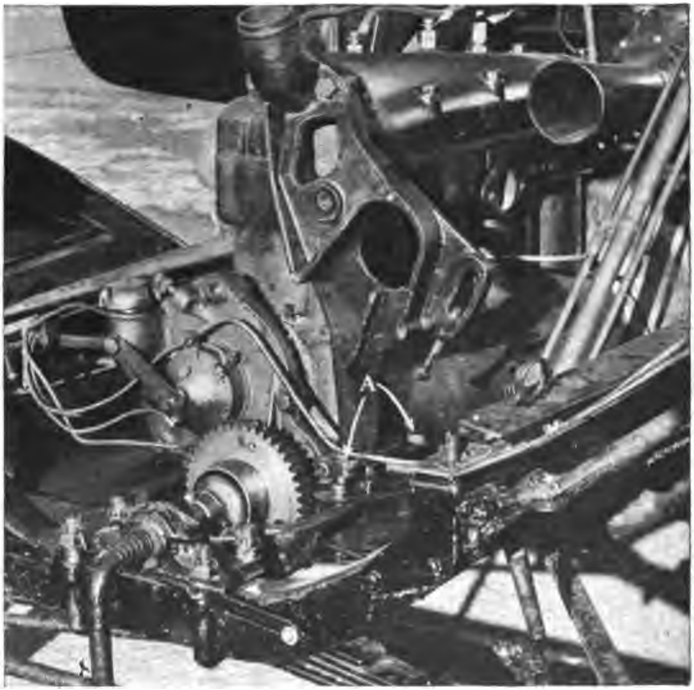


Fig. 92—Mounting bracket for Genemotor in position on Ford engine

removed or with its contact surface on the commutator reduced, as normal charging current cannot be procured. The starting motor is supposed to spin the engine at sufficient speed to secure ignition from the magneto. If the engine does not fire promptly, pull the priming rod; if still no success is met with, examine the ignition system and adjustment of the carbureter. Remember the starter supposedly is only intended for cranking the engine. In very cold weather it is advisable to turn the engine over by hand a few times before using the starting motor, thus preventing an excessive drain on the battery.

The latest model of the Genemotor for the Ford car is a single-unit, two wire, 12-volt equipment. The electrical unit is mounted on the left-hand side of the engine on a special bracket attached to the engine and mechanically connected to the engine crankshaft by a silent chain. The regulation of the generator is by the third-brush method. This system is designed for installation on any 1917 or 1918 Model T Ford car. On early cars it will be necessary to fit the engine with a new crankcase having required increase clearness in the nose pan.

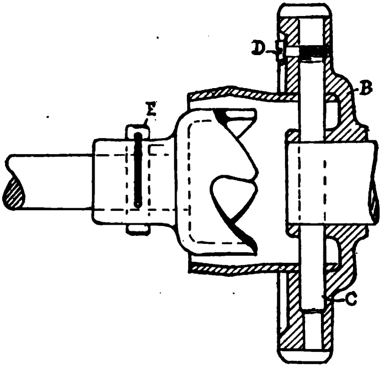


Fig. 93—Method of mounting driving sprocket and fan pulley on crankshaft

Preparation of Engine

The following parts should be carefully removed:
Radiator with water pipe and elbows.
Starting crank and ratchet.

Fan bracket complete.
Fan drive pulley on engine crankshaft.
Engines bolts.

Mount the Genemotor supporting bracket on the right-hand side of the engine, facing the radiator, by loosely bolting the water connection top of the bracket to the water connection of the engine, taking care to re-insert the packing gasket in its proper place. Then insert the two thick washers in the counterbores at A, Fig. 92, in the base of the engine under the lower foot of the bracket. Enough of the thin washers then should be

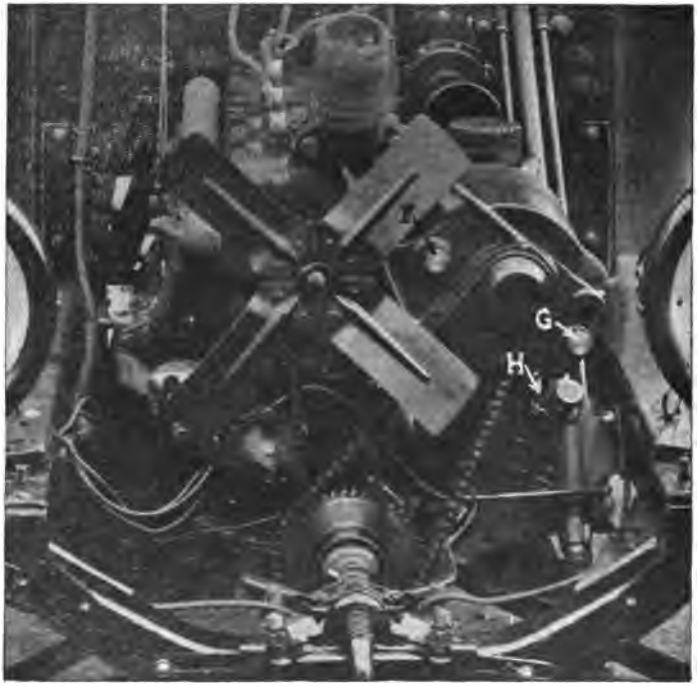


Fig. 94—1918 *Genemotor mounted on Ford engine* placed on top of one or both of the thick ones, as the case may be, to make the bracket stand perpendicular and bring the flanges of the water connection at the top together and into line. Then insert bolts A with heads on top of bracket foot and tighten bracket foot solidly onto washers, using the Ford crown nuts on the bolts from below. Then set up the top water connection bolts tightly.

Assemble the driving sprocket B onto the crankshaft, Fig. 93. Line up the holes in the sprocket with that in the crankshaft and drive pin C into place. Lock the pin by inserting screw D over top of pin, not forgetting to use a lock washer under the head of the screw.

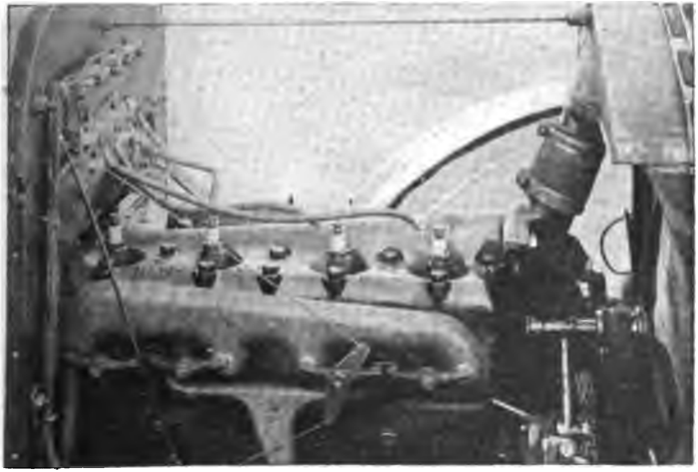


Fig. 95—Installation of primer rod

Push the starting crank ratchet into pulley and assemble the chain over the large sprocket B. This can be done without disconnecting the links. Also slip the fan belt under pulley. Replace the starting crank, using new spring pin E, Fig. 93, to lock crank and ratchet together.

If necessary to replace the fan belt at any time, pull out the pin E with pliers and push the starting crank ratchet into pulley.

This will give room for removing the belt between the crankshaft and ratchet and eliminate the necessity of removing the radiator.

Bring the pinion end of the Genemotor against the rear face of the bracket with pinion shaft and pinion projecting forward through the opening provided. Pass the chain over the pinion and insert bolts F and G, Fig. 94, but do not lock tight.. Swing the Genemotor upward on bolt F as a pivot by the adjusting screw H until the chain is sufficiently tight so the maximum deflection with ordinary finger pressure on the under side of the chain is ⅜ inch. Set up bolts F and G tightly.

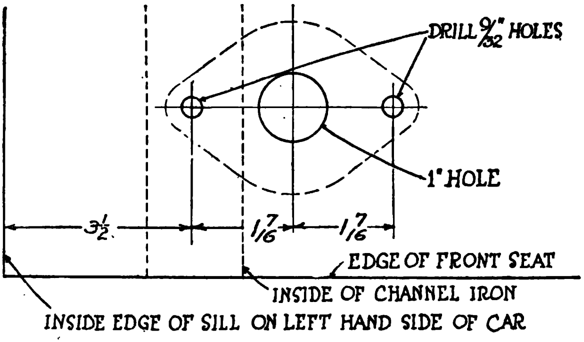


Fig. 96—*Proper position of holes for mounting starter switch*

Remove the fan shaft from the Ford fan and reassemble with new fan, first packing fan body with bearing grease. Mount the fan on the engine and tighten the belt to proper tension. Replace radiator and water connections. Attach the primer rod and lever, Fig. 95, using the Ford primer rod originally coming through radiator. Mount the starting switch under the heel board, Fig. 96.

Battery Installation

In the battery installation on touring cars, sedans and town cars, the battery cradle is of a new type, locating the battery under the body of the car as in Fig. 97. Access to the battery is gained by loosening the floor boards of the car. The cradle should be placed on the car frame and the battery inserted and clamped fast between the supporting beams by tightening the two clamping bolts A as in Fig. 97. Tighten the clips B, holding the supporting beams to the car frame, first slightly shifting the cradle forward or backward as necessary to allow for the slight difference in width of the floor boards so that the battery can be inspected and removed through the body of the car. In case the battery supplied is not sufficiently long to entirely fill the cradle a block of wood should be placed between the forward end of the battery box and the cradle, Fig. 98, before setting up clamp bolts in order that the battery may be firmly held in place.

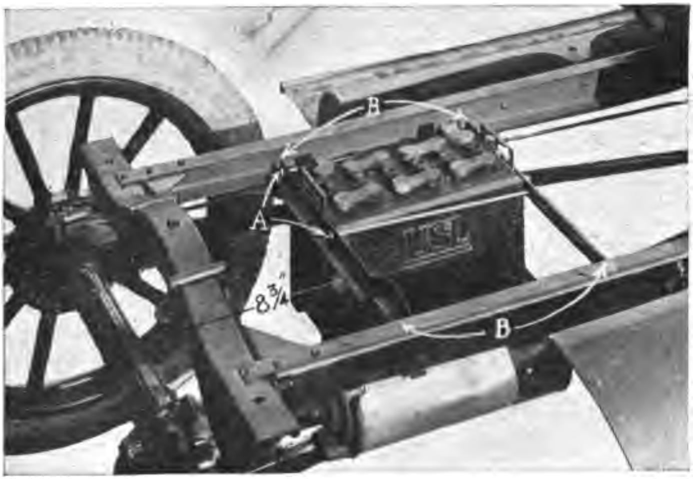


Fig. 97—Location of battery under the frame of the car

On runabouts the mounting is the same as for touring cars except that the floor board should be cut away as in Fig. 99. The two wooden cleats in the figure and the necessary cover may be cut, Fig. 100, from the cover of the packing box in which the equipment was received. Due to the location of the gasoline tank it will be necessary to locate the cradle on coupelets, Fig. 101, after first shortening the depth of same as in Fig. 102.

Wiring Diagram

Spring the lighting switch into place on the steering column so that the switch buttons are on top and approximately 6 in. below the steering wheel. The lighting switch has two points, 1, all lights bright and, 2, all lights dim. Wire the head and taillights with leads supplied. Note particularly that it is necessary to cut off the cable from the main headlight lead and splice on for left-hand headlight. Connect the Genemotor to the starting switch and battery, taping the leads together near the switch for support. After connecting the negative battery lead to the nega-

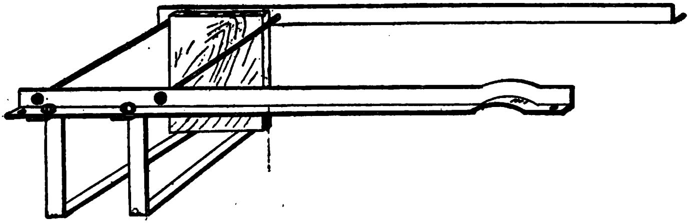


Fig. 98—Construction of battery cradle

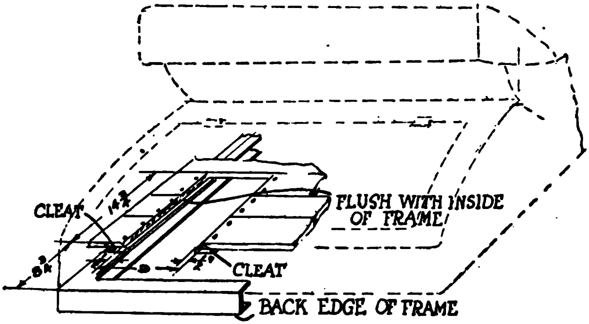


Fig. 99—Opening in floor of Ford runabout for storage battery

tive terminal, touch the positive battery terminal with the positive lead with all switches off. If no spark is noticed connect permanently.

Be sure to connect the positive terminals on battery to positive on Genemotor and negative to negative, according to markings on Genemotor, battery and cables; otherwise the system will not operate. All the bulbs should be 12-16 volts. Turn the engine over slowly by hand to see that everything is free and clear. Starter and lights are now ready for use.

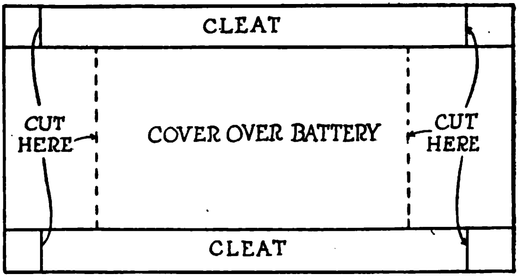


Fig. 100—*Wooden cleats to be used in mounting storage battery*

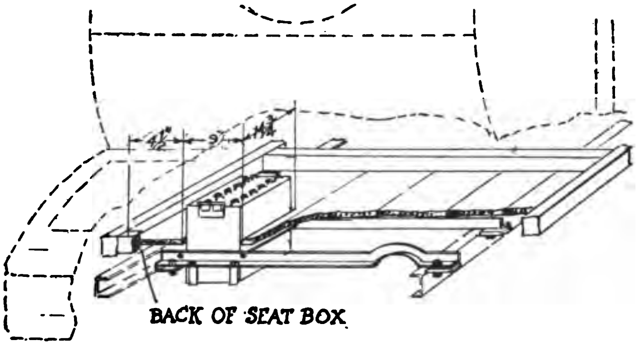


Fig. 101—*Location of battery cradle on Ford coupelet*

Important Precautions

Put distilled water in the battery every two weeks. Grease the chain every 500 miles and keep proper tension. Lubricate ball bearings at either end of Genemotor with a few drops of non-acid oil every 1000 miles. Never put oil or grease on the commutator. If the commutator is rough or dirty, clean with fine sandpaper only. Never operate the Genemotor with battery removed unless the Genemotor terminals first are connected with a copper wire or cable; otherwise the Genemotor will overheat and injure the windings. Lights cannot be used with battery removed.

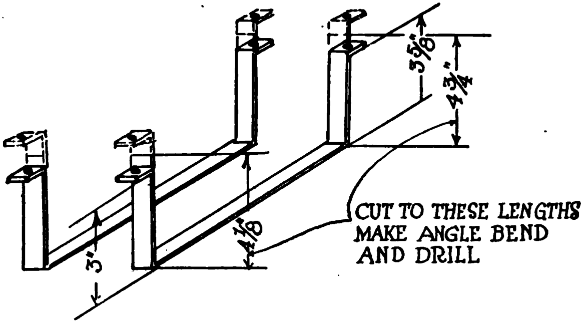


Fig. 102—*Proper depth of battery cradle supports for Ford coupelet*

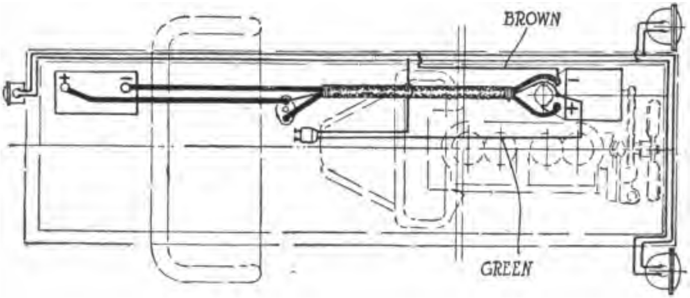


Fig. 103—*Wiring diagram of* 1918 *Genemotor for Ford car*

In extremely cold weather it is advisable to break away the engine by hand, turning it over a few times before applying the starter, thus preventing undue drain on the battery.

The starter is designed to spin the engine at sufficient speed to secure ignition from the magneto. If the engine does not fire promptly, pull the priming rod; if still no success is met with, examine the ignition system and adjustment of carbureter. Remember the starter is only intended for cranking the engine and should not be used to move the car. Should the starter fail to turn the engine over, before attempting any adjustments try cranking by hand to be sure that the crankshaft is free to turn.

CHAPTER VIII

Disco System for Fords

THE Disco electrical system for the Ford car is a single-wire, two-unit, 6-volt system. The generator is driven direct from the engine crankshaft by a silent chain, and the starting motor transmits its power to the engine crankshaft through a Bendix drive which automatically engages a gear mounted on the shaft of the generator. Both the generator and the motor are mounted on a special bracket which is attached to the left-hand side of the engine, as shown in Fig. 104. The starting switch is of the electrically-operated type, and the output of the generator is controlled by an electro-magnetically operated regulator. A cut-out of the electromagnetic type controls the connection between the generator and the battery.

Preparation of Engine for Installation

Before removing any part of the engine make sure the carbureter is properly adjusted and that ignition is operating satisfactorily. Remove the hood, radiator and fan from the car. Also remove the first and third crankcase bolts, on the right side of the cylinder casting as viewed from the front of the car, and place on the cylinder casting the bracket provided for supporting the Disco. The holes in this bracket will register with the two crankcase bolts which have been removed. Fasten this bracket down securely with the two longer cap screws provided for this purpose, taking care to place the spring lock washers under the heads of screws. The dog at the end of the crank handle will be of no further use, as this is now a part of combination fan pulley and crankshaft sprocket, and when replacing the starting crank it will be only necessary to drive into the hole in the crank handle the 3/16 by 2-inch steel pin supplied with the outfit.

Drive out the 3/8-inch pin that holds the fan pulley in place, making sure that the pin is in a vertical position to allow it to drop through the hole in the bottom of the front motor support, Remove the pulley, and place on the crankshaft the combination sprocket and fan pulley provided, using the special ⅜-inch pin for pinning same to the crankshaft. This pin is necked at one end, which should enter last so that the neck will indicate with the hole drilled through the fan pulley and sprocket. A cotter pin is provided for inserting in this hole to prevent the crankshaft pin from working loose. Remove the cylinder head retaining bolts Nos. 1, 2 and 3 on the right-hand side, replacing it with special bolts provided, thus securing the top supporting bracket. Remove the cylinder head retaining bolt No. 4 on right-hand side and replace it through the bracket of the solenoid starting switch, thus securing it in place.

Great care must be taken after removing the cylinder head retaining bolts not to allow any dirt or filings to enter these holes or there will be danger of cracking the cylinder casting when replacing these bolts.

Installing Electrical Unit

Place the Disco motor and generator assembly on the lower supporting bracket, when tapped holes in the brackets on same will register with the slotted holes in the supporting brackets. The four hexagon-head cap screws provided for this purpose may be screwed in place, taking precaution to use lock washers under the heads of same. These screws are distributed as follows, two through top supporting bracket and two through lower supporting bracket. The upright screw in the lower supporting bracket should be run down as far as possible and the silent chain placed around the sprockets, the ends being brought together and pinned. To facilitate reaching the chain-tightening screw mentioned, it will be advisable to cut out a small piece of the soil pan so that this screw may be operated by a socket wrench from underneath the chassis. The four hexagon-head cap screws mentioned may be set up snugly enough to support the Disco motor and generator assembly, when the upright screw in the lower supporting bracket may be run up until the chain is of the proper tension, it being borne in mind that too tight a chain will cause undue strain on the bearings of the generator and a loose chain will allow whipping and its consequent troubles. When the proper tension of the chain has been obtained, the four hexagon-head cap screws may be tightened securely.

Next place the fan in the original position, after equipping it with the small split-fan pulley provided with the outfit. Place the fan belt to run on this new pulley, and tighten the belt as before. It will be found necessary to cut about ⅛ inch off each side of fan belt to bring it down to ¾ inch width to run on the new pulleys.

Combination Switch Box

Place the combination switch box on the steering post so that the face of the ammeter is about ½ inch below the horn button. Secure it to the post with the clamp and four screws provided for this purpose. Drill a ¾-inch hole through the dash in a vertical line above the steering post and as close as possible to the flange of it for the flexible conduit. The conduit should be clamped to the steering post with the clamp provided, about midway between the switch box and the dash. Drop the flexible conduit vertically on the other side of the dash, and secure it near the end with a pipe clip.

Wiring and New Choker Rod

Study the wiring diagram carefully, and make all electrical connections as securely as possible.

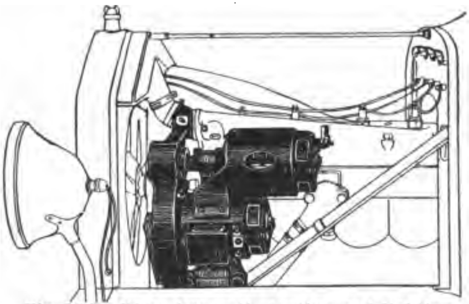


Fig. 104—Disco two-unit starting and lighting system mounted on the Ford car

Place the battery box on the running-board about 3 inches from the front end. The outside edge of the box should be flush with the edge of the running-board. Drill six holes to correspond with the holes in the bottom of the battery box. Fasten the battery box to the running-board with the four bolts provided.

Place the battery in the box and fasten it by the hook bolts furnished. Cut large holes in the splash plate in direct line with the large holes in the side of the battery box. These holes should be made by making two diagonal cuts at right angles to each other and bending the edges in to provide a large surface and prevent abrasion of insulation on heavy cables. The long heavy cable is to be used from the postive, +, post of the battery to the solenoid switch, Fig. 105. The short heavy cable is to be used from negative, —, terminal to the ground, which may be made by drilling a ⅜-inch hole in the chassis frame opposite the holes in the splash plate and battery box. Scrape all paint from around this hole until bright surface of metal shows. Securely bolt the terminal of the cable to the frame using the $\frac{5}{16}$-inch by ¾-inch bolt furnished. Do not connect the wires to the battery until installation is entirely complete and all is in readiness for starting.

The engine now should be cranked by hand to make sure that everything is lined up properly and that chain does not bind. Make a careful examination to see that all bolts and nuts are in place and properly fastened and that all electrical connections are correct and properly taped up to insure insulation.

Remove the old choker rod and replace it with the one supplied, allowing it to run through the small brace furnished, which should be anchored under the head of the bolt in the flange connecting the carbureter to the intake manifold. Allow the front end of the choker rod to pass through the hole in the radiator, through which the original choker rod passed. Bend a ring in the outer end of the rod after the radiator is in place. Drill a hole in the toe board 2 inches from the top directly back of the carbureter and place the short 3/16-inch rod supplied through the hole, connecting it to the loop in the main choker rod, and replace the button on the other end. Fasten the rear end of the main choker rod to the arm of the choke valve on the carbureter. See the wiring diagram in Fig. 106.

Remove the steel water pipe between the radiator and the engine, and replace it with the special pipe provided for this purpose. Replace the radiator on the car, and hook up the water manifold as before. Fill the radiator with water, and everything will be in readiness to start the engine.

First connect the battery leads. To start the engine, place the spark and throttle levers in the customary position, that is, spark

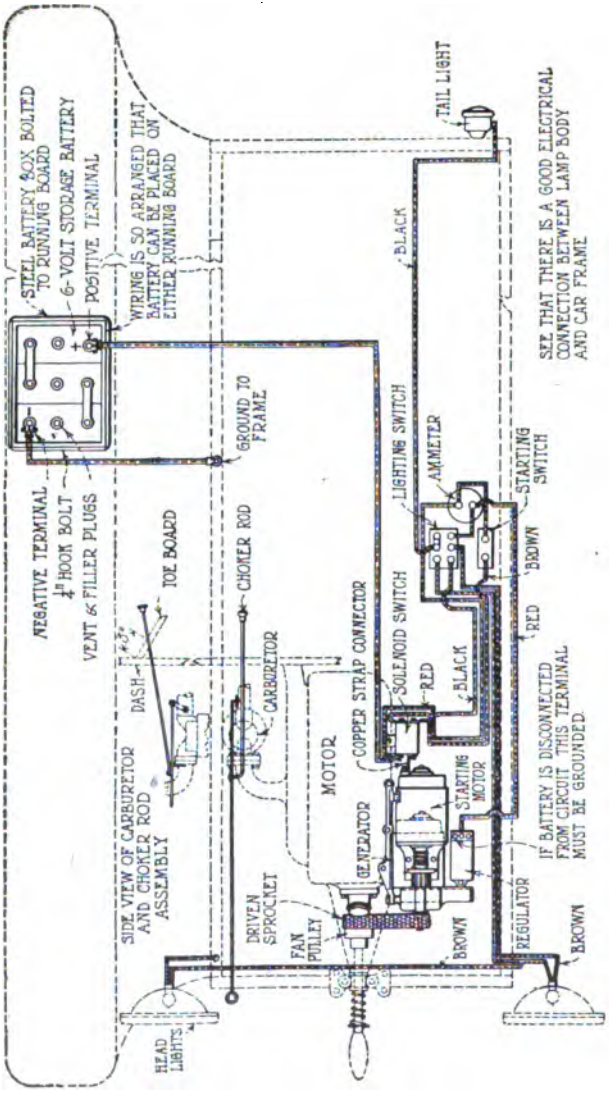


Fig. 106—*Complete wiring diagram of the Disco two-unit starting and lighting system for the Ford car*

retarded and throttle about a fourth open. Depress the small button on the left-hand side of the switch box, and the starter will spin the engine, provided proper adjustments have been made. The engine should pick up immediately under its own power. If necessary, push down the choke rod on the toe board to facilitate starting. Run the engine slowly at first until you are sure that the outfit has been hooked up correctly and that all bolts and nuts are tight and that the outfit is functioning properly. Speed the engine up slightly, and note if the ammeter shows charge. The instrument should show from 7 to 11 amperes charge according to the condition of the battery, 7 amperes when the battery is fully charged and 11 amperes when the battery is very low. Do not under any consideration attempt to alter the charging rate.

Fig. 105—*Some of the smaller parts of the Disco starting and lighting system for the Ford car*

See that each cell of the battery is filled with electroylte to a height of ¼ inch above the plates.

Whenever you replace a disconnected or removed battery, be sure to place the terminal of the wire from the solenoid switch on the terminal of the battery marked positive, +.

When the outfit is completely installed, the battery must be inspected with a hydrometer to insure its being fully charged.

Its hydrometer reading should be from 1285 to 1300. Very often there is considerable delay in delivering a battery by freight so that its strength may have become exhausted in transit, or it may have been subjected to rough handling through which the electrolyte has been partly spilled out. It is absolutely necessary that the battery should be fully charged and in good condition in every way before the installation can be called complete.

If for any reason it is necessary to run the engine with the battery disconnected, it is of the utmost important that the wire from the center post of the regulator be removed and a short wire placed under either outside post of the regulator, taking care that it shall have a good electrical connection thereto. The other end of this wire should be securely grounded to the frame of the generator or some metal part of the engine. This will insure the user against liability of damage to his generator.

Do not under any consideration connect the battery wires until installation is complete and engine is ready to start. Whenever making any adjustments or repairs to the electric system be sure to disconnect the battery first. .

CHAPTER IX

Fisher System for Fords

THE Fisher system for the Ford car is a two-unit, 12-volt, combined single- and two-wire system. The starting and generator units are shown in Fig. 107. The lower unit is the generator, and it is connected to the crankshaft by a silent chain running over gears mounted on the crankshaft and generator shafts respectively. The motor shaft is geared to the generator shaft by a special set of gears so arranged that power may be transmitted from the motor to the generator shaft and not in the opposite direction, so that the motor armature does not revolve only when it is used in starting the engine. The cranking rate is approximately 20 to 1 and the generator drive rate 1⅕ to 1. The generator is provided with inherent regulation, which prevents an overcharge of the battery at high speeds. An electromagnetic cutout controls the connection between the battery and the generator.

Preparation of the Engine

The engine should be adjusted so that it is running smoothly before dismantling any of the parts. Then remove the radiator with upper hose connection and lower water manifold loosened at the side of the cylinder, starting crank, fan and pulley on the end of the crankshaft for driving the fan.

Place the new sprocket E, Fig. 108, on the end of the crankshaft, driving the pin H through the cross hole in the end of the crankshaft, burring the hole slightly so it cannot leave its position. This secures the sprocket to the crankshaft of the engine. Pin F is placed in the sprocket before shipment.

Then slip the pulley marked A over the end of the sprocket up to the shoulder. Secure the pulley by several center punch marks between the end of the sprocket and the internal diameter of the pulley at D. If it is desired to retain the Ford starting crank in place—this is preferable to carrying it in the tool box—cut $\frac{3}{16}$ inch off the ratchet clutch, C, Fig. 108, at the shoulder B. The original hole in ratchet clutch C and starting crank are not disturbed. If there are burs on the ratchet clutch or if it is too large to enter the chain sprocket, the tips must be filed or turned down in a lathe.

Mounting Generator—Motor Unit

Remove the right-hand bolt of the top water connection marked A, Fig. 109, and the second bolt on top of the cylinder marked B. If there are any rough spots or burs under either of these bolts they must be removed. Remove the supporting bracket C from the generator-motor unit and place the bracket in position as shown in Fig. 109. Between the bracket C and the water connection is a thick steel spacer washer. The bracket must be securely bolted in place against the water connection by bolt B. The careful placing of the bracket and the clamping of these bolts are essential to the successful operation of the installation. After these bolts are securely in place, turn the set screw D in Fig. 109, until it rests securely and firmly on the engine casting and, when firmly bedded, lock it in position by tightening the lock nut. The purpose of this set screw is to take the strains between the shaft of the electrical unit and the crankshaft of the engine, and the end of the screw must rest on the casting, otherwise the chain may be injured.

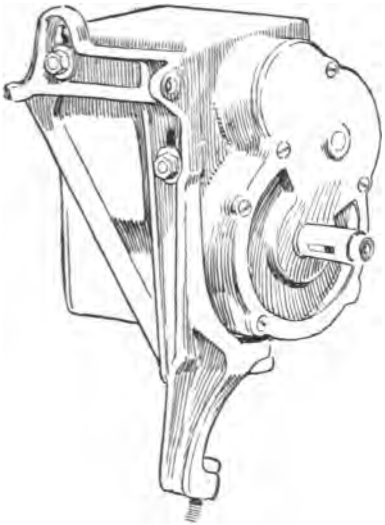


Fig. 107—*Starting and generator units of Fisher system for Ford*

Place the starting unit E on the mounting bracket and clamp it in its lowest position with washers and nuts on the studs. A long shank T-wrench is best to use for this purpose. The chain which is fastened together by a bolt and cotter pin may now be put in position. Roll the chain under the sprocket F and on sprocket G on the electrical unit as in Fig. 109. Bring the two end links together and slip the bolt through with the head toward the engine and put the washer and cotter pin in place. Tighten the chain by loosening the nuts on the studs holding the unit in place and the locknut H, on set screw I. Then screw set screw I up until the chain feels taut when pressed with the fingers. Tighten the nuts on the studs and the lock nut H on the set screw I. Turn the engine over a few times by hand when you have assembled the starting crank to see that everything is clear before trying to use the starter. The slack in the chain should be taken up quite frequently during the first few hundred miles, as the life and service of the chain are greatly increased by keeping it under the proper tension, especially while it is stretching.

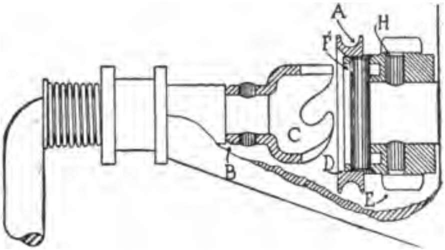


Fig. 108—*Method of mounting new sprocket for Fisher system*

Separate the split pulley A, Fig. 110, and clamp it on the shaft of the fan, between the brass pulley and the fan blades, by the two screws. The diameter of the bore of this pulley is slightly under the neck of the fan so it may be necessary to file it with a round file so it will fit the neck of the fan pulley. After this pulley is in position, hook the round belt J, Fig. 109, over the pulley on the crankshaft and the pulley on the fan.

Remove the plug from the top of the starting and lighting unit and squirt half a pint of BB transmission grease by a grease gun into the gearcase, replacing the plug after inserting the grease. This quantity of grease will be ample for six months, average running. A front view of the installed unit is shown in Fig. 111.

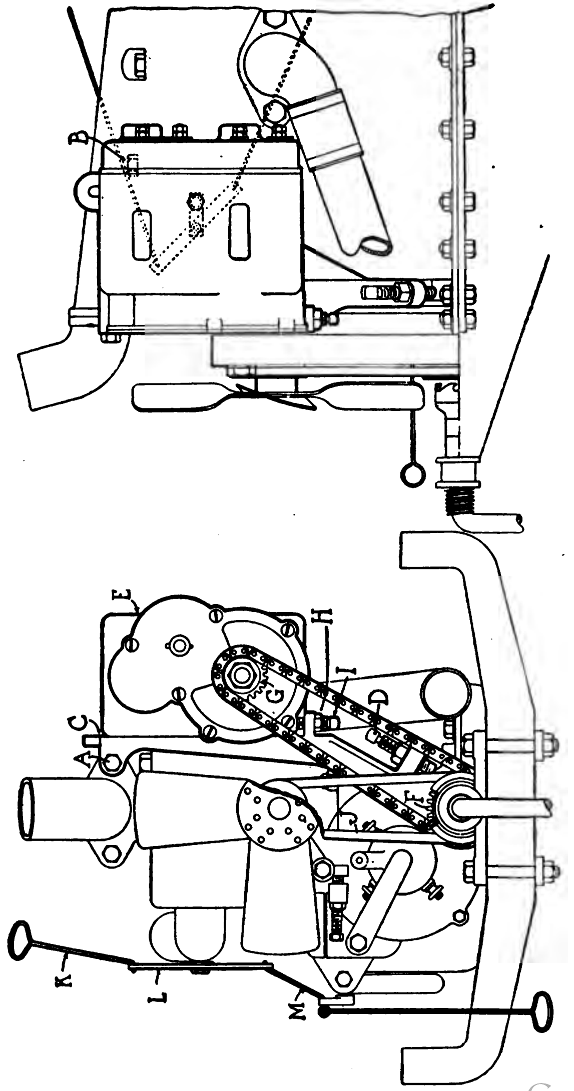


Fig. 109—*Front and side views of the Fisher starting and lighting system for the Ford car mounted in position on the engine*

Installing Battery and Wiring

The battery box may be located on either running-board, but should be placed in such a position that it will not interfere with the car doors, and the battery itself when in the box will be easily accessible. Holes must be drilled in the splash plate to accommodate the battery cables.

The battery cables should be protected with short pieces of ½-inch flexduct where the wires pass through the holes in the battery box and splash plate. The 1-inch flexduct should be used about the wires between the transmission cover and engine hanger on the left side, letting it extend back past the brake pedals. Mount the instrument board carrying the starting and lighting switches, ammeter, relays and dash lamp under the cowl dash to the left of the steering column. A front view of the instrument board is shown in Fig. 112. The length of the wires can now be adjusted to suit this particular location. A complete wiring diagram is shown in Fig. 113, and the wiring should be installed as follows. Run the large negative starter cable 4 from the negative, —, terminal of the battery through the flexduct to the negative terminal on the motor. Install a heavy cable from the positive, +, terminal of the battery to the left-hand terminal of the starting switch, Fig. 113, but do not make the electrical connection at the battery. All the terminals on these cables should be soldered and the binding posts tightened with a wrench.

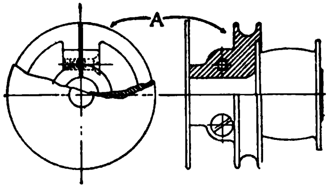


Fig. 110—*Method of mounting new fan pulley, over old one for Fisher system*

Install a lighting cable from the lower brush on the generator, marked G in Fig. 113, to the terminal marked G on the relay. Connect another lighting cable between the terminal marked S on the generator and the terminal marked S on the relay. Install the electric side lamps and connect them in series, running a lighting cable, marked 12 in Fig. 113, from the lighting switch to the left-hand lamp, thence to the right-hand lamp and to ground. Disconnect the wire going to the headlights from the original switch and connect it to the new lighting switch. From one side of the dash lamp run a lighting cable to the tail lamp, being sure to ground one side of the tail lamp so as to complete the circuit. When the wiring is completed as outlined, trace each circuit carefully and be sure that all connections have been made in accordance with the diagram. With all switches open touch the positive battery wire to the positive battery terminal, and if no spark occurs on breaking this contact the battery connection may be made permanent. Solder and tape all joints and tighten all binding nuts with a wrench. Check the indication of the ammeter by turning on the lights. It should show a discharge. Start the engine and increase its speed. Note the indication of the ammeter with the lamps turned off. The ammeter should indicate a charging current as soon as the cutout closes.

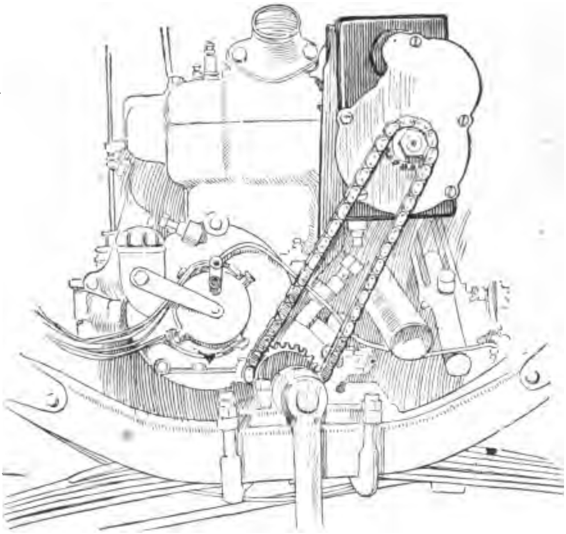


Fig. 111—*Front view of installed generator-motor unit in Fisher starting and lighting system*

Each equipment is furnished with a priming attachment so that the priming valve may be operated from the seat. The installation of this equipment is shown at K, L and M in Fig. 109.

Operation, Care and Precautions

The electrical unit must not be run with the battery disconnected, unless the small wire is removed from the binding post on the generator. Clean the brushes on generator and the motor occasionally. Watch the adjustment in the chain, and lubricate it with heavy engine oil or transmission grease. About once a week for ordinary use of the car, put three or four drops of oil in the small holes of the upper and lower bearings on the commutator end of the electrical unit. Examine the battery about once a week, and put distilled water in it often enough to prevent the liquid from getting below the upper edge of the plates. Examine the connections to the battery to make sure they are solid and making good electrical connections. Remove any appearance of corrosion and cover the terminals with vaseline. It is not advisable to use the starter needlessly, that is, do not crank the engine with the ignition switch purposely open.

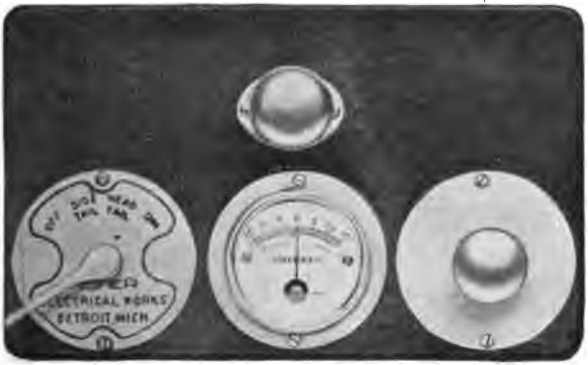


Fig. 112—*Front view of instrument board for Fisher system for the Ford*

Do not continue cranking the engine if it does not start and run under its own power after cranking for 5 to 10 seconds at most.

Examine the ignition system, carbureter, gasoline supply, etc., to try and ascertain the difficulty. Always make sure that the ignition spark is not too far advanced when cranking the engine, as it may backfire and cause serious damage. The brushes and the commutator on the generator and the engine should be cleaned occasionally.

The bulbs recommended for use with this system are 7- to 8-volt tungsten for the side, dash and tail lamps. The candlepower of any two lamps of the same voltage that are to be connected in series should be the same. Thus the dash and tail lamps should have the same candlepower if they have the same voltage rating.

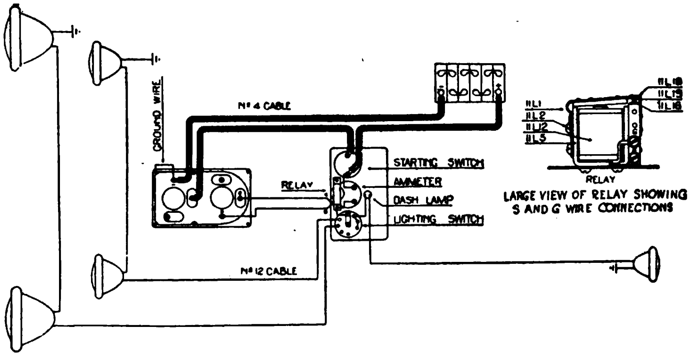


Fig. 113—*Complete wiring diagram of the Fisher electrical system for the Ford car*

CHAPTER X

Splitdorf System for Fords

THE Splitdorf electrical system for the Ford is a single-unit, two-wire type in which the generator output is controlled by a special field winding. The battery consists of six cells arranged in two groups of three cells each. These two groups of cells are connected in series by a special starting switch when the starting motor is in operation and in parallel when the starting switch is in its normal position, that is, the starter operates on 12 volts and the lamp on 6 volts.

Preparation of Engine

Remove the radiator and all the water connections from their clamp couplings at the engine. Remove the fan and its mounting, and turn the engine over by hand until the pin holding the fan pulley is perpendicular, and then drive the pin out through the hole in the engine base. Drive out the pin holding the ratchet clutch on the end of the starting crank and pull out the crank.

Remove the bolts marked B and C in Fig. 114, but before removing the nut A entirely from the bolt tie a piece of twine around the threads below the nut to prevent the bolt from dropping in the motor base or the crankcase. If the bolt should happen to drop it will remain in the hole and a sharp blow on the crankcase directly under the bolt will cause it to jump forward and it may be caught with the fingers.

Mounting Crankshaft Sprocket

Place the adjustable bracket in position and secure it to the engine, using the bolts supplied at B and C and the nuts formerly on the old bolts. The bolts holding the lower part of the bracket should be tightened, as it is important that this part be held tight to the engine.

Now place the split taper sleeve A, Fig. 115, on the engine shaft and drive the pin B through the holes in the sleeve and shaft, which should be in alignment with each other, until it is flush with the sleeve on both sides. With the key in position in the sleeve drive the sprocket C on the sleeve, the keyway registering with the key. The nut D now should be turned on the end of the sleeve. This causes the sprocket to become well seated on the taper portion of the sleeve and at the same time causes the split end of the sleeve to grip the engine crankshaft.

Replace the starting crank, start the chain under the sprocket and with the starting crank turn the engine over slowly until the chain is drawn through for about half of its length, making sure that the chain is working freely.

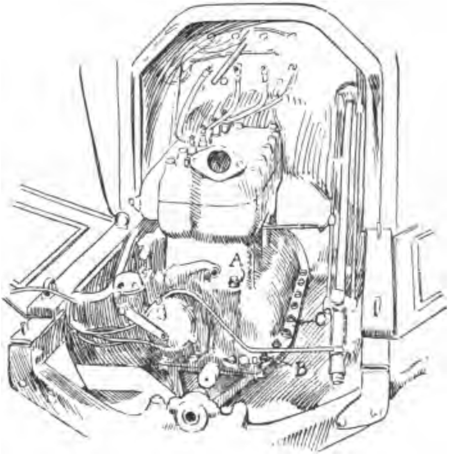


Fig. 114—*Bolts that must be removed to install the Splitdorf mounting bracket*

Mounting the Electrical Unit

Fasten the electrical unit to the adjustable bracket with the three bolts and lock washers furnished. This operation can be accomplished very easily by tilting the bracket. Place the chain in position over the sprocket on the end of the shaft of the electrical unit, join the ends of the chain with the pin and lock the pin with a washer and cotter pin. Align the crankshaft and generator motor sprocket by the adjustable bracket hinge bolt. Adjust the chain to its proper tension, that is, without any undue amount of slack.

The aluminum fan pulley is made in two parts and clamps over the Ford fan pulley. The new pulley is held in position by four screws and lock washers. Fill the recess of the fan with grease and replace the fan, using the original bearing stud, and place the fan belt in position and adjust it to the proper tension.

Installing the Wiring

Prepare the dash of the car for the wiring by cutting the holes shown in Figs. 116 and 117. Hole A in Fig. 117 is for the ignition switch. Hole B is for the lighting and dimming switch and hole C for wires leading to the indicating automatic switch. The hole A may be omitted unless a magneto is to be used for ignition.

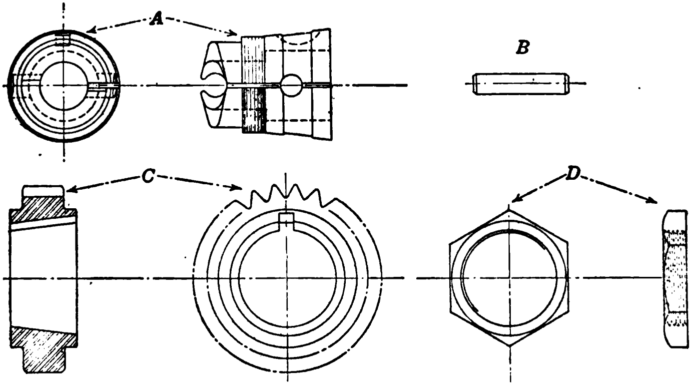


Fig. 115—*Driving sprocket and taper sleeve upon which it is mounted*

Bore a ⅞-inch hole in the permanent floor board, shown in Fig. 118, following the dimensions given for its location. Install the starting switch with the front of the switch lengthwise with and facing the front right-hand side of the car. At the same time the lighting and dimming switch should be placed in position, with the coil end of the switch facing down.

All the wire terminals are marked to correspond with similar marks on all parts of the installation. Lay the wiring assembly in the frame of the car, connecting the wires to the front of the dash, as shown in Fig. 116. Reference to Fig. 119 will assist the installation. Connect the wires to the indicating automatic switch in accordance with the diagram on the back of the switch, after which fasten the switch to the steering column about 3½ inches from the dash. Connect the wires, as marked, to corresponding terminals on the electrical unit and also to the starting switch.

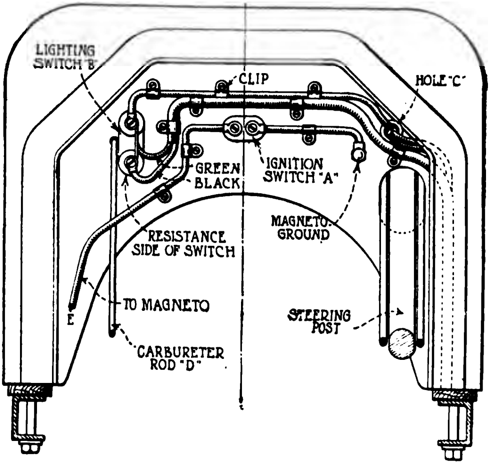


Fig. 116—*Method of installing wiring on front of dash for Splitdorf system*

Holes should be drilled in the cross braces of the frame in front to accommodate the headlight wires. Place the wires in position and secure them with clips, using a conduit to protect the leads where they pass under the starting crank. These clips and conduit are supplied with the equipment, and the method of mounting them is shown in Fig. 119.

Installing Storage Battery

Prepare the curved running board guard, or splash apron, for the battery leads and the running-board for securing the battery box, as shown in Fig. 118 and fasten it securely in place with bolts, nuts and lock washers, all furnished with the outfit. Place the battery in the box with the outside, end terminals, toward the car. Pass the extension cables under the wood sill and over the channel steel frame of the car, connecting the extension leads from the battery to the starting switch as marked and to corresponding terminals on starting switch and battery. The method of installing the battery cables is shown in Fig. 120.

Indicating Automatic Switch

The indicating automatic switch is connected in the circuit between the generator and the storage battery. Its primary function is to close the circuit between the generator and storage battery when the voltage of the generator exceeds the voltage of the battery, and it also serves to break or open this circuit when the voltage of the battery exceeds the voltage of the generator. The switch is equipped with an indicating dial which shows whether or not the battery is being charged.

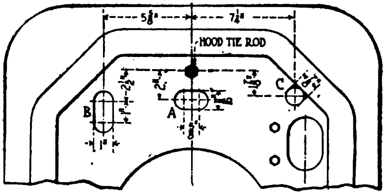


Fig. 117—*Location of holes that must be drilled in dash for Splitdorf system*

Special Starting Switch

The starting switch performs the additional function of connecting the two sections of the storage battery in series when the starting motor is being operated. When the starting switch is depressed the two 6-volt units of the battery are connected in series by certain connections in the switch and a 12-volt current is supplied to the electrical unit, which now is operating as a motor. This change in battery connection, however, does not affect the voltage applied to the lamps, as they are connected

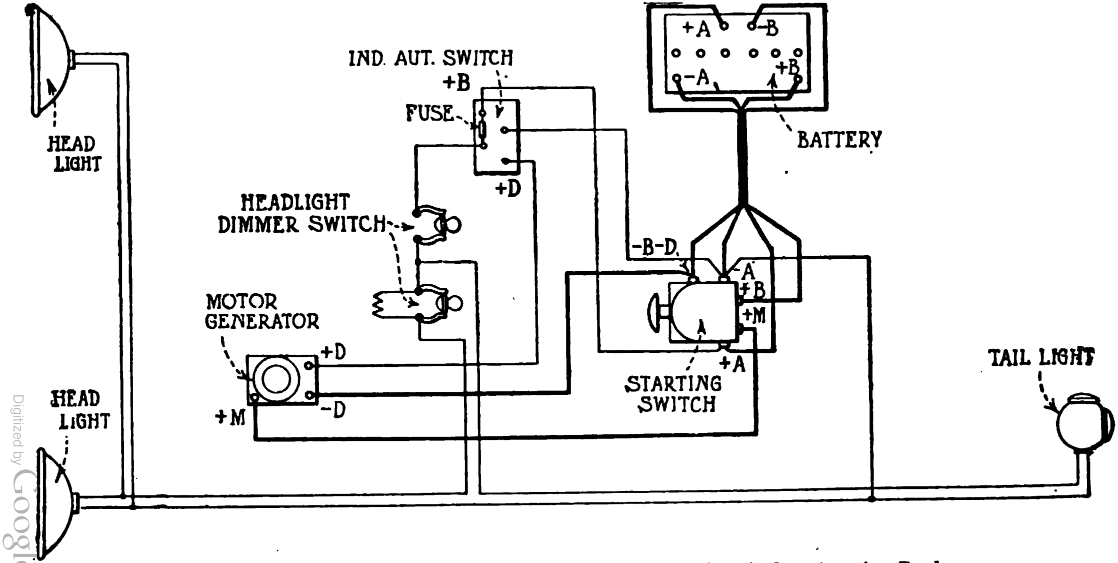


Fig. 119—*Complete wiring diagram of the Splitdorf electrical system for Fords* to one or the other of the 6-volt sections all the time. When the starting switch is in its normal position the two 6-volt sections of the battery are connected in parallel and charged as any 6-volt battery would be charged.

Path of Current

The generator and starting motor circuits may be traced by reference to the wiring diagram given in Fig. 119. Starting with the terminal marked + D on the generator pass along the small wire to the terminal on the indicating automatic switch marked + D, through the heavy winding in the automatic switch and out to the terminal marked + B, then to the terminal + A on the starting switch, where the current divides, one branch going to the + A on the battery and through the battery to — A on the starting switch and the other branch going to the jumper in the switch to + B on the starting switch, then to + B on the battery through the battery to — B on the starting switch. The point — B — D on the starting switch is common to the negative terminal of both sections of the battery and is connected to the negative terminal of the generator marked — D.

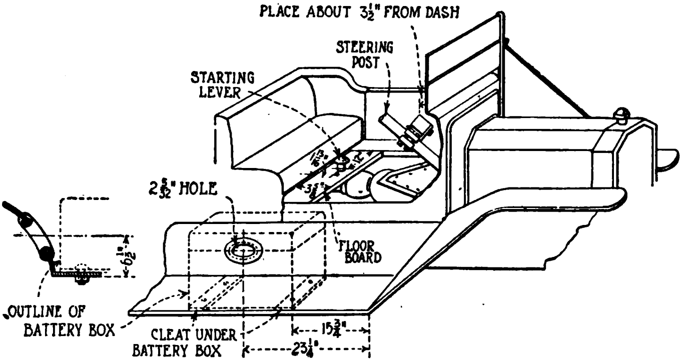


Fig. 118—*Directions for locating different parts of Splitdorf system*

When the starting switch is depressed the circuit may be traced from the battery terminal + A to + A on the starting switch, through the starting switch to the terminal + M, then to the terminal + M on the electrical unit, through the winding of the electrical unit to the terminal marked — B — D on the starting switch, then to — B on one section of the battery, through this section of the battery to + B on the battery, then to + B on the starting switch, through the switch to — A on the switch, to —A on the battery, through the battery to + A which completes the circuit.

Care of Electrical Equipment

The electrical unit should be oiled at least every 1,000 miles by inserting five or six drops of medium high grade oil in the oil holes at the ends of the unit. Watch the alignment of the electrical unit so that the chain runs perfectly true, and keep the chain reasonably tight.

Keep the commutator clean, wiping it off with a cloth. If it becomes blackened or roughened it may be cleaned and smoothed up with a piece of 00 sandpaper. Never use emery paper. Carefully clean all dust and particles of sand from the commutator and from between the segments after using the sandpaper.

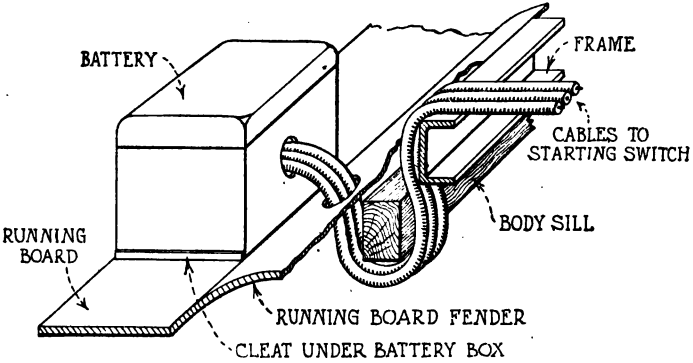


Fig. 120—*Method of installing battery cables*

Do not change the position of the brushes and do not alter the tension of the brush holders. See that the brushes make good electrical contact with the commutator surface, that they are not unduly worn and that the brush leads do not rub against the armature.

If the electrical contacts in the starting switch wear abnormally, see that the foot pedal of the switch is not stuck in the floor board. The hole in the floor board should be large enough to prevent the pedal spring from rubbing against the floor board. See that proper contact is made when the starting switch returns to its normal position. The contacts and various electrical connections can be examined by removing the cover of the starting switch.

If the battery is removed from the car or disconnected for any reason, the electrical unit must be protected by connecting a wire across the posts + D and — D.

To prevent an excessive drain on the battery and to increase the ease of starting in cold weather, it is imperative to lead the carbureter choke rod to the dash, where it will be readily accessible at all times.

CHAPTER XI

Dyneto System for Fords

THE Dyneto system for Fords is a single-unit, single-wire system. The electrical unit is mounted on a special bracket attached to the left side of the engine, and its armature shaft is connected to the crankshaft of the engine by a silent chain. The fan is driven by a belt which runs over a special pulley mounted on the end of the shaft of the electrical unit. A front view of the unit complete is shown in Fig. 121.

Preparing the Engine

In addition to the tools supplied with the Ford car, you will need a small wrench or strong slip pliers and a hacksaw.

Remove the radiator brace rod from the radiator, disconnect the carbureter primer wire from the carbureter so it will lift off with the radiator. Remove the radiator by taking off the nuts on the bolts that hold the radiator to the frame, disconnecting the rubber hose connections where they are fastened to the elbows on the engine.

Remove the fan bolt by unscrewing the nut at the back and remove the fan. Take the bolt out of the fan and cut the old fan pulley off with the hacksaw just where the bevel begins, or nearest to the fan, and smooth off the surface with a file. Fill the small pulley with heavy grease. Place the red felt washer over the hub left on the fan, then place the pulley over the hub. Place the fan bolt through both the fan and the pulley, compressing the felt washer by forcing the pulley on the fan until the shoulder on the bolt sticks out of the pulley about $\frac{1}{64}$ inch, and then screw the four set screws as tight as possible, turning each screw an equal amount until all are tight. The fan is now ready to be replaced on the engine in the old position after the other equipment is installed.

Take the ratchet clutch off of the end of the starting crank by removing the pin, and take out the starting crank. Drive the pin out of the fan pulley on the crankshaft and remove the pulley. Remove the second, fourth and fifth bolts from the engine base on the right side as you face the car. Remove the nut on the bolt to the right of the first cylinder, and if this bolt turns while taking off the nut a piece of twine should be tied around the threads on the bolt before the nut is removed entirely to prevent it from falling into the crankcase.

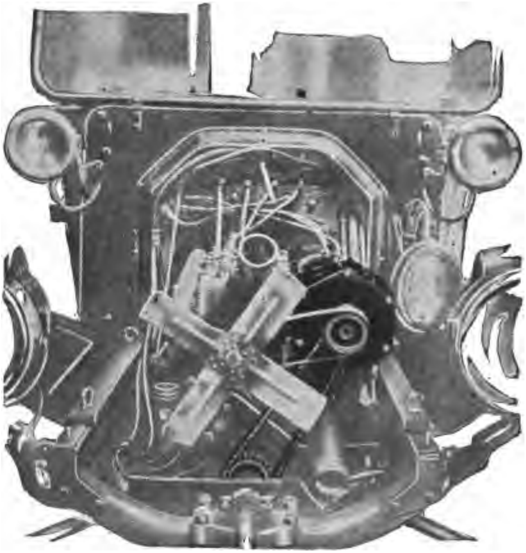


Fig. 121—*Installation of the Dyneto starting and lighting system on Ford*

Installing Driving Sprocket

Place the twenty-six-tooth sprocket on the front end of the engine crankshaft, and fasten it securely in place with the $\frac{3}{8}$-inch pin supplied with the outfit. Insert the lock spring in the groove provided in the sprocket. Replace the starting crank and attach the ratchet clutch to it by means of the pin.

Installing Mounting Bracket

Place the mounting bracket in position on the side of the engine with the ½-inch hole over the bolt to the right of the first cylinder, placing the washer over the bolt first and using the special nut with the holes in it to go on the bolt. Place the remaining three bolts in position, placing the spacers and washers under the bracket and lock washers on all the bolts below the nuts. All four nuts now can be tightened.

Mounting Electrical Unit

Mount the electrical unit on the bracket with the studs through the bushings in the bracket and allow the unit to rest in this position without placing the nuts on the studs. Insert the outer two bushings in the bracket until they come through flush.

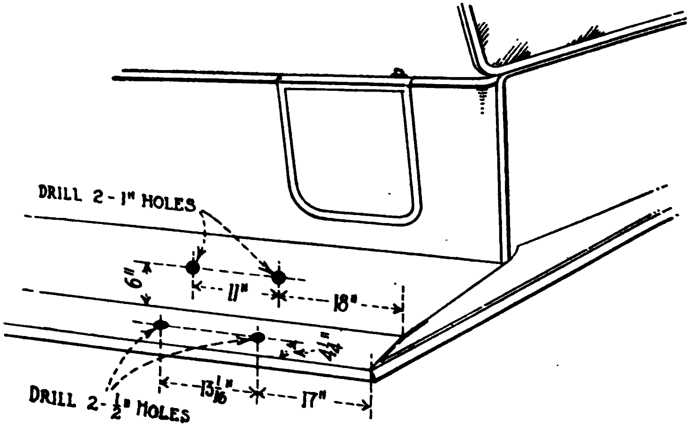


Fig. 122—*Location of holes in running board and splash plate for battery mounting bolts and cables*

Disconnect the chain where it is joined with the special links and place it in position around the driving sprocket on the crankshaft and the small sprocket on the shaft of the electrical unit and reconnect the two ends. The small pin for connecting the chain links should be toward the radiator or the front of the car.

All four of the adjusting bushings now may be screwed into the mounting bracket an equal amount to keep the electrical unit level and at the same time tighten the driving chain, being careful to get the tension adjusted so you can just move the chain by slapping it with your fingers. Clamp the adjusting bushings, and before turning the nuts the last turn push the electrical unit toward the rear of the engine as far as you can, which will put the chain in alignment. Then tighten all four of the nuts. Turn the engine over a few times by hand to see that everything is free and that the timer rod does not strike the driving chain. Should the rod strike the chain, bend the rod to clear it in all positions.

Remove the bolt on the outer side of the flange on the carbureter, and place the small sheet steel positioning bracket on the bolt, replacing the bolt and nut. The bracket should project upward. The primer wire should go through the small hole in the bracket and be fastened to the lever on the carbureter where the old primer wire was attached. Drill a small hole in the dash for the new primer wire to go through so that it is convenient to pull from the driver's seat, while starting the motor.

Put the fan in position and mount it with the old fan bolt, putting a special washer between the pulley and the bracket. Place the fan belt in position and tighten it as in ordinary cases.

Mounting the Battery

Drill two ½-in. holes in the right running board, as shown in Fig. 122, and two 1-in. holes in the splash plate. Place the battery box in position with the two wood pieces under the box, having the holes in line with those in the bottom of the box, then place the battery in the box, and put the long bolts through the holes in the battery box and running board. Use short wood pieces under the running board for the bolts and iron washers, then place two nuts on each bolt, one serving as a lock nut.

Starting and Lighting Switches

The starting switch has three positions marked off, neutral and start. The switch may be locked in the off position so that the car cannot be started even by hand, as the ignition also is controlled by the same switch. The neutral position is for long drives with a fully charged battery, and in this position the armature of the electrical unit will operate just the same mechanically yet it will not generate any electrical energy and charge the battery needlessly. The position marked start is for starting. This position also is for running when the lights are being used or the battery is being charged.

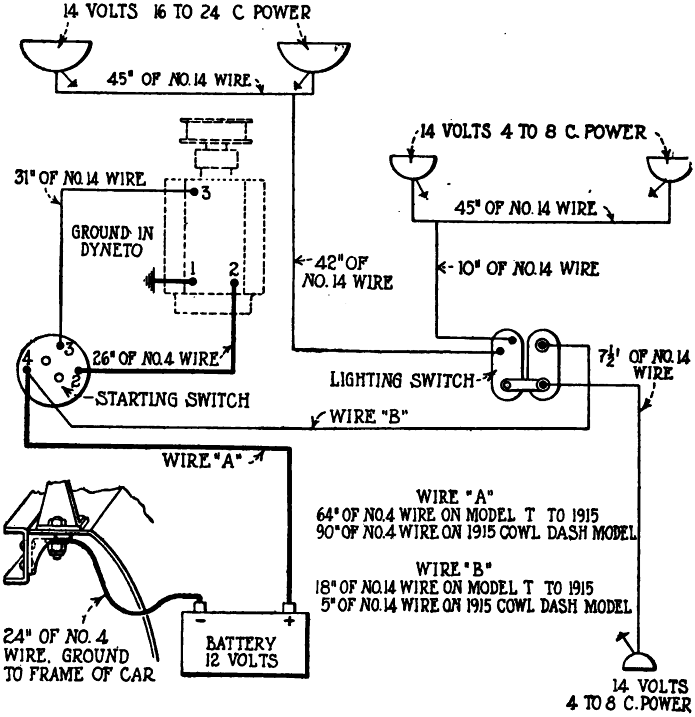


Fig. 123—Complete wiring diagram of the Dyneto electrical system for Fords

The lighting switch should be installed within easy reach of the driver. Its electrical connections are shown in the wiring diagram in Fig. 123.

Electric Wiring

After the electrical unit, storage battery and starting switch are in place the wiring easily may be installed. The proper size of wire and the approximate lengths for each connection are shown in the wiring diagram in Fig. 123. After all the wires are in position they should be anchored securely to prevent their working loose at their terminal connections or coming in contact with rough edges and corners. Be sure that all electrical connections are good and tight and that all joints in the wires are well insulated. The large battery wires should be well insulated where they pass through the splash plate. The wire connected to the negative terminal of the battery should be grounded to the frame of the car as shown diagrammatically in Fig. 123.

The lamps recommended by the Dyneto company are marked on the wiring diagram. The type of base required will depend upon the style of socket in the lamps on the car or those selected by the owner if new lamps are put on.

Care of Electrical System

Oil the electrical unit every few days, perhaps once a week for ordinary driving, wiping off all excess oil and any dirt which may accumulate. Examine the wiring to see that all connections are tight and that the wires are not being damaged by rubbing against sharp edges or corners. Inspect the commutator occasionally, and should it be found dirty or rough clean it off with a rag and smooth down the surface with a piece of 00 sandpaper. Be sure that the brushes are clean and make good contact with the commutator. If the brushes are removed for any reason, be sure to replace them in exactly the same position.

Keep the battery clean and securely fastened in place and above all do not allow it to stand in a discharged condition. Fill each cell with distilled water each week or so to replace the liquid that has evaporated.

Watch the chain tension, especially for the first few hundred miles after the system has been installed, as it will stretch quite a bit.

If the electrical unit fails to start the engine when the starting switch is thrown to the position marked start do not leave the switch in that position but turn it to the off position. Turn on the lamps, and if they burn brightly, try starting the electrical unit again and watch the lamps. If they do not decrease in candlepower, it is quite likely that there is an open circuit in the starting circuit, at the switch contacts, terminal connections, or the brushes may not be in electrical contact with the commutator due to excessive wear of the brushes or a dirty commutator. Examine the circuit carefully, and remedy any apparent trouble.

If, with the lamps turned on and the starting switch thrown to the start position, the lamps drop slightly in candlepower and the electrical unit does not turn the engine over, the trouble may be due to a loose connection, roughened or dirty commutator, brushes worn or not well fitted to the surface of the commutator, weak brush springs, or the armature or field windings may be grounded or otherwise defective.

If, with the lamps turned on and the starting switch thrown to the start position, the lamps burn very dimly or not at all, the trouble is probably due to the battery, and a thorough inspection of it should be made to see that the terminals are clean and that there is ample solution in each of the cells to cover the plates.

If the motor starts but turns the engine very slowly, the trouble is likely due to too much resistance in the circuit or a defective or discharged battery. The high resistance may be due to the use of too small wire, loose terminals at the battery, starting switch or electrical unit, poor electrical contact in the starting switch, rough or dirty commutator, worn out brushes, insufficient tension on the brushes to keep them in contact with the commutator. Look for weak or partially discharged battery, which may be due to grounds or short-circuits, unnecessary use of the lights when the engine is not run enough to keep the battery charged, or unnecessary cranking of the engine when it will not pick up, due to poor adjustment of the carbureter or faulty ignition.

CHAPTER XII

North East System for Fords

THE North East system for Fords is a two-wire, 12-volt, or 24-volt, single-unit chain-drive type of equipment, but it is different from the usual form of chain drive inasmuch as two separate chains are used in forming the mechanical connection between the crankshaft of the engine and the shaft of the electrical unit. As the system is no longer in production this section will be devoted to the operation and care of the installation. Wiring diagrams of the system are given in Figs. 124, 125 and 126.

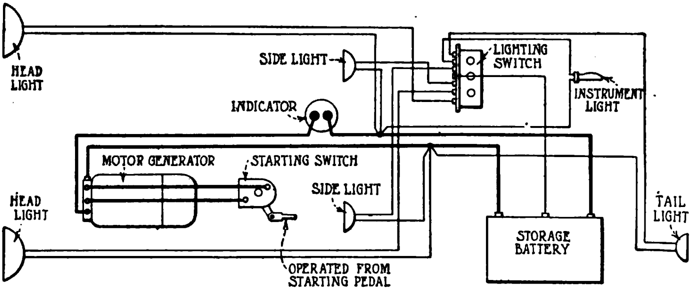


Fig. 124—*North East electric starting and lighting system furnished for Fords during the last half of* 1913 *and first half of* 1914

Operation and Care

In starting the engine turn on the ignition switch and set the spark lever and gas throttle to the best running position. Press the starting-switch button the full length and hold it there until the engine runs under its own power and then allow the starting button to return to its normal position. If the engine should fail to start after spinning it 5 to 10 seconds, open the starting switch and make a careful examination of the following: See that the spark plugs are clean, the carbureter properly adjusted, the ignition in good order, gasoline at the carbureter.

The chains and sprockets must be kept clean, and after each cleaning apply a little grease to the inside surface of the chains. Be careful that the chain sprockets be kept in good alignment and a moderate tension maintained in each chain.

Keep all parts of the electrical equipment clean and inspect the various connections occasionally to see that they are tight and making good electrical connection. Keep the cover on the rear of the electrical unit in place. It should be removed only when it is necessary to inspect the commutator and brushes. Inspect the commutator occasionally and keep it clean and smooth and the brushes in good contact.

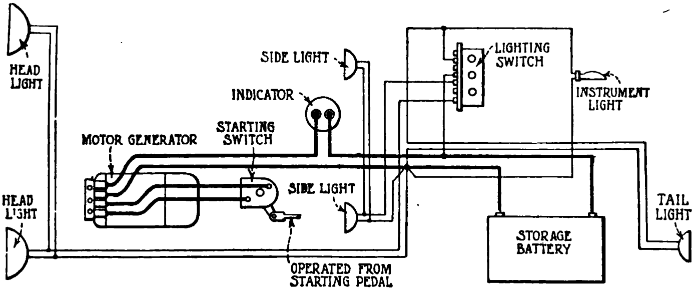


Fig. 125—Flexible-lead type of North East electric starting and lighting system for Fords

If the electrical unit is removed for any reason, it is advisable to tape the ends of the cables to prevent damage which may result from short-circuits or grounds occurring. The end of the cables should be carefully tagged so that no mistake will be made in reconnecting them when the electrical unit again is installed.

In case it is necessary to run the electrical unit with the battery removed or disconnected, remove the small 10-amp. fuse located over the brushes inside the detachable cover at the rear end of the electrical unit. Be sure to replace this fuse when the battery again is connected in circuit. The blowing of this fuse may be the cause of the generator not charging the storage battery. If such is the case, it should be replaced with another one of the same kind and same current capacity, but under no circumstances use a wire instead of the fuse, as the generator may be seriously damaged without the protection of the fuse.

The bearings of the electrical unit will not require any outside lubrication as they are packed in a special lubricating compound.

The wiring should be inspected to see that it is properly supported and protected at points where there is danger of exposed ends coming together or where there is a possibility of damaging the insulation. Inspect the starting and lighting switches occasionally for loose connections and dirty or burnt contacts.

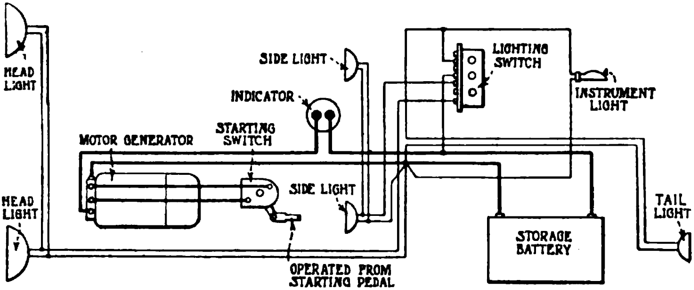


Fig. 126—Binding-post type of North East electric starting and lighting system for Fords

If the battery becomes discharged under normal use, without apparent cause, and the fuse under the cover on the rear end of the electrical unit is not blown, the wiring and connections should be examined carefully. If there are no shorts or grounds on the system and the battery continues to lose its charge, there is more than likely something wrong with the battery. If the car stands idle for any great length of time, it is best to run the engine every three or four weeks to liven up the battery, as an idle battery will discharge gradually.

CHAPTER XIII

Lighting Installations for Fords

THERE are a few installations of simple lighting generators with or without battery but which have no means for cranking the Ford engine. During the last few years, the stock Ford has been electric lighted from the magneto. Consequently, th number of special lighting installations is small. Three of th more common installations are described briefly here:

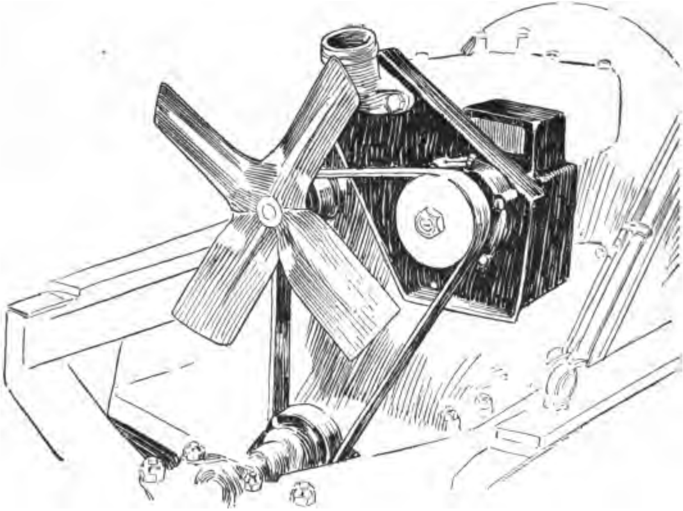


Fig. 127—*Installation of Genolite charging generator on a Ford car*

Genolite System for Fords

The Genolite electrical equipment for the Ford car consists of a charging generator and 6-volt storage battery. The generator is mounted on a special bracket which is attached to the left side of the engine and driven by an extra long fan belt, which runs over a flanged pulley on the shaft of the generator, as shown in Fig. 127. The storage battery is arranged to be mounted in a steel box on the running board and is held securely in place by strong holddown bolts, which are attached to the handles of the battery and pass through the running board with lock washers and nuts on the under side.

The output of the generator and the connection between the generator and the battery are taken care of by a Ward Leonard combination cutout and controller. The controller is of the constant-current type, that is, it tends to maintain the current output of the generator constant for all car speeds above approximately 9 m.p.h. The controller is adjusted for a charging current of 7 amperes. The combined cutout and controller is mounted integral with the generator.

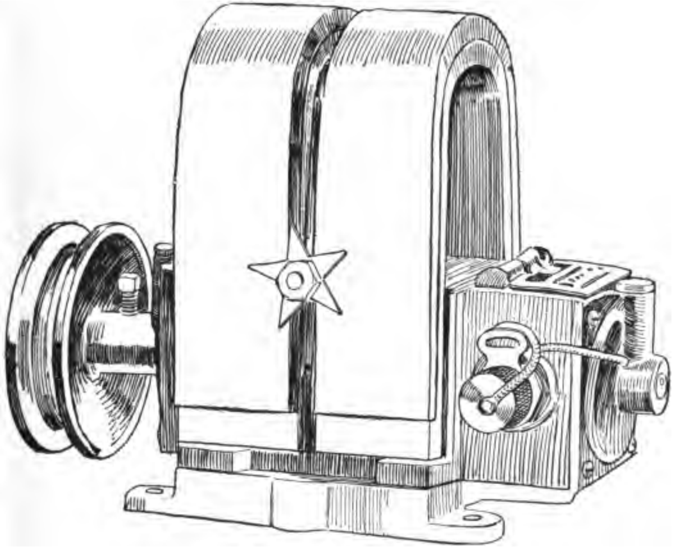


Fig. 128—*Hendricks permanent magnet type of charging generator*

The control switch is mounted on the steering post within easy reach of the driver at all times. It is of the two-gang type, and the lights may be turned on full candlepower or they may be dimmed for city driving. The dimming of the headlights is accomplished by using bulbs equipped with two filaments. Two of this type of bulbs are supplied as a part of the Genolite equipment. One of the filaments gives a full candlepower, and the other gives a dim light for meeting anti-glare regulations.

Hendricks System for Fords

The Hendricks lighting generator is of the permanent-magnet type. It is arranged to be mounted on a special bracket attached to the left side of the Ford engine and is driven by a special V-shaped belt, which runs over a small pulley on the end of the

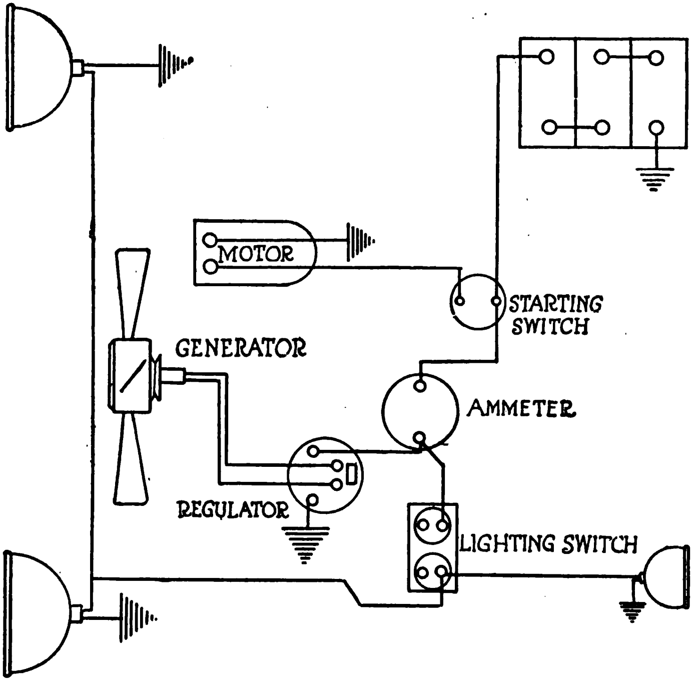


Fig. 129—Wiring diagram of Kemco starting and lighting system for Fords

generator shaft and a larger special pulley, which is attached to the fan and driven by the fan belt. The battery is arranged to be mounted on the running board, and the connection between it and the generator is made and broken by an electromagnetic cut-out. A complete Hendricks permanent magnet generator is shown in Fig. 128. All the necessary wires, each cut to the proper length, are supplied with each outfit.

Kemco System for Fords

The latest Kemco system is of the 6-volt, two-unit, single-wire type. The generator and starting motor both are mounted on the same special casting, which takes the place of the timing gear cover.

The generator is of special construction and is driven direct from the crankshaft of the engine by a V-belt, which is claimed not to stretch or slip as an ordinary belt.

The power of the motor is transmitted to the crankshaft of the engine by a strong roller chain and a special set of gears. The roller chain becomes inoperative the instant the engine starts to run under its own power faster than the electrical motor tends to drive it by an overrunning clutch mounted in the large gear on the engine crankshaft.

A wiring diagram of the complete installation is shown in Fig. 129.

CHAPTER XIV

Atwater Kent System for Fords

BEFORE starting the installation of the type K-2 Atwater Kent ignition system for Fords the following list of material should be checked carefully to see that everything required is on hand. The different essential parts are shown in Fig. 130.

Material Included in Outfit

1—Four-cylinder K-2 Unisparker mounted on special gearcase cover to fit in place of standard Ford gearcase cover, shown at A in the figure.

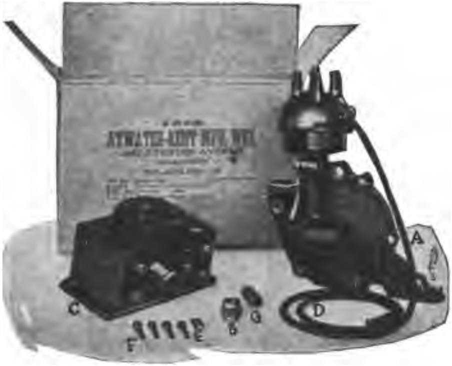


Fig. 130—*Essential parts of the* K-2 *Atwater Kent ignition system*

2—A spiral drive gear, B.

3—One Atwater Kent ignition coil with switch complete, C.

4—Flexible double-conductor cable for connecting the Unisparker and coil. This cable is attached to the Unisparker when shipped and is shown at D in the figure.

5—Two cotter pins for pulley, E.

6—Four wood screws, F, for attaching the coil to the dash.

7—A special socket wrench, G.

Additional Material Required

In addition to the material supplied the following should be provided:

Eleven feet of high-grade secondary wire having an outside diameter not exceeding $\frac{5}{16}$ in.

Flexible stranded primary wire—if car is a roadster, 15 feet; if touring car, 25 feet.

Six cells of dry battery or a 6-volt storage battery.

Tools Required

The only tools required for completing the installation are screwdriver, pair of pliers, monkey wrench, hacksaw and pocket knife.

Making the Installation

1—Remove Ford coil box and all ignition wiring.
2—Remove radiator as follows:
  a—Drain off circulating water.
  b—Remove the right headlamp when facing the radiator.
  c—Unbolt upper water connection and loosen hose connection on side of engine, so as to leave both sections of hose connected to the radiator. It is easier to unbolt the water connection flange than to remove and replace the upper hose.
  d—Loosen brace-rod check nut at dash and unscrew rod from radiator.
  e—Remove nuts from feet of radiator and radiator may be lifted off.

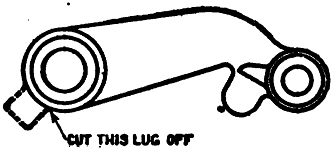


Fig. 131—*Cut off lug on the fan bracket as indicated*

3—Remove fan and fan bracket and cut off lug, as shown in sketch, Fig. 131.
4—Remove adjusting screw and locknut from present gearcover and place same in the new gearcover furnished with outfit, Fig. 132.
5—Remove commutator by taking off nut, washer and pin, sliding off contact arm and commutator.
6—Remove cotter pins from pin in fan pulley on crankshaft, Fig.

133, and drive out pin which runs clear through the shaft. This pulley must be moved forward on the crankshaft about ½ inch to set the new gearcover in place, after which it is moved back to its original position, new cotter pins being provided in case the original ones are damaged in removing.

7—Remove gearcover, using the special socket wrench provided with the outfit for taking out the bolts which are next to the crankshaft.

8—Remove semi-circular piece of felt from groove in Ford gearcover where it fits over the crankshaft and replace in new gearcover furnished with outfit.

9—Place spiral gear of Atwater Kent system on camshaft in the place formerly occupied by the commutator and set up tight, applying plenty of grease to teeth of spiral gear.

10—Be sure that the paper gasket used between the old gearcover and crankcase is in good condition and is transferred carefully to the new installation.

11—Place the new gearcover complete with Unisparker in position on the motor, sliding it into place, as shown in Fig. 134. After it is in position insert the two end bolts, marked B, Fig. 132, also screw in the fan bracket bolt C, thus obtaining the proper alignment of the gearcover, after which the other bolts may be set up.

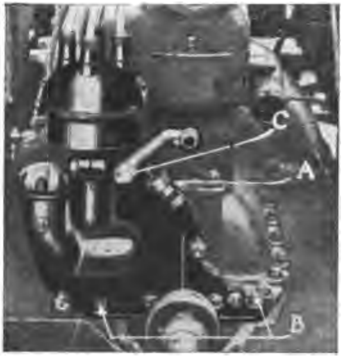


Fig. 132—*Atwater Kent type K-2 Unisparker in position on a Ford*

12—Next, the fan pulley on the crankshaft should be set back into position, inserting the pin and fastening this in turn with the two cotter pins included with the outfit.

13—Remove spark plug in cylinder No. 1 next to radiator.

14—Bring piston in No. 1 cylinder up exactly to high dead center at top of compression stroke.

Timing the Engine

1—Set clamp under Unisparker so that Unisparker may be turned in its bearing. For accurate setting it should be clamped just tight enough to turn fairly hard. Then, grasping the Unisparker firmly, turn it slowly and steadily in the opposite direction to the hands of a clock until a click is heard. Stopping exactly at the point where the click was heard, lock the Unisparker fast by tightening up clamp bolt. In case the Unisparker is turned so that the cable which projects from the side interferes with the fan, turn the Unisparker a full quarter turn until the next click is heard.

2—Take off distributor cap.

3—Note the direction in which the distributor block on the upper part of the distributor points and replace the cover. The terminal to which it points will connect to the spark plug in cylinder No. 1 and the spark will be timed to occur exactly on center. The diagram in Fig. 135 shows the relation of the distributor terminals to the spark plugs and in applying this to your installation the distributor terminal to which the distributor block points always will be No. 1 and will connect to cylinder No. 1. The other terminals will connect to the remainder of the spark plugs in accordance with the order of firing of the Ford engine, which is 1-2-4-3, the other distributor terminals connecting to these plugs in rotation.

If spark timing is done accurately according to these instructions, the timing will be correct for the maximum power, speed and flexibility of the engine.

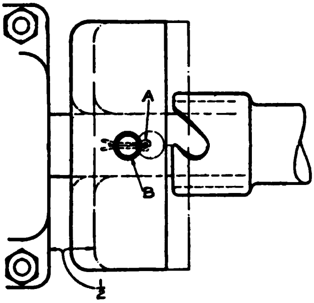


Fig. 133—*Removing pin that holds the pulley on the crankshaft*

Once set, the spark is controlled automatically by the governing device in the base of the Unisparker, and the spark is timed with automatic precision for any speed. It always is retarded automatically for slow starting and for hill climbing, and automatically advanced for any speed of which the engine is

Fig. 134—*Placing new gear cover and Unisparker in position*

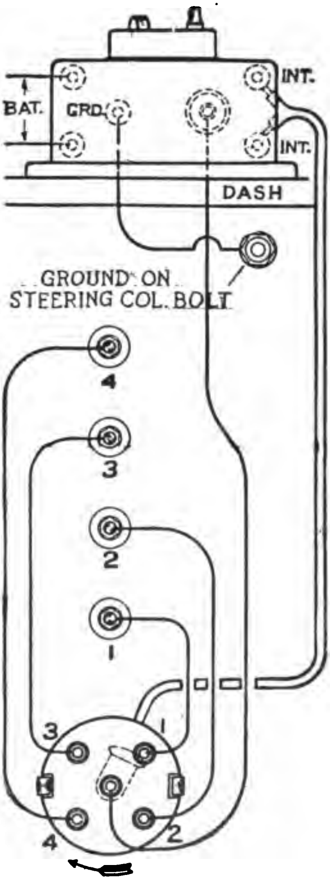


Fig. 135—*Diagram of connections for Atwater Kent ignition system.*

capable. Once properly timed, it should require no further attention.

Before proceeding with the wiring, complete the mechanical installation as follows:

1—Replace breather cap taken from old gearcover.

2—Replace fan and bracket on new gearcover, making sure that grease cup on fan is full of grease.

3—Replace radiator as follows:

a—Set radiator in position.

b—Connect upper and lower water coupling. Note that gasket is in good condition.

c—Bolt radiator in place, taking care not to set up springs under the bolts too tightly.

d—Replace cotter pins in lock nuts.

e—Connect brace rod from dash to radiator, screwing it first into radiator and then tightening up lock nut at dash.

4—Replace lamp.

5—Replace spark plug in No. 1 cylinder.

6—Mount Atwater Kent coil on center of dash so that round head of brace rod fits in space counter-bored for it on back of coil. The necessary screws for mounting the coil on dash are provided with the outfit.

After mounting coil, proceed with wiring, as follows:

Run the black primary cable, which is connected to the interrupter, up along the brace rod, fastening it thereto with a few turns of adhesive tape, and thence, through one of the holes left by the original coil wires, to the coil where the two wires are connected to the two binding posts at one end of the coil marked "INT," Fig. 135.

Secondary Ground Connection

From the bottom of the coil a wire should be run from the post marked "GRD" through hole in dash to one of the bolts fastening the steering column to dash. In making this connection to this bolt, the wire should be bared for about 1½ inch, bent into a U-shape and inserted between dash and washer. Do not wrap wire around bolt several times.

The main high-tension, or secondary, terminal of the coil is protected with an insulating cover, which unscrews to enable connection to be made at binding post.

Cut away the insulation from the secondary wire for a distance of about 1⅛ in., cutting the insulation back neatly and leaving no stray wires, also being careful not to cut the wire when removing the rubber covering. This is shown by A, Fig. 137.

Unscrew the secondary terminal cover and push this up on the wire in such a way that after the connection is made it can be brought down over the connection and screwed tight.

Pass the wire about three-quarters of the way through the hole in brass terminal.

Bend the end of the wire back on itself to make one complete turn, as shown in B and C, Fig. 137. These wires should not be soldered.

Bring down the insulating collar and screw it down on the terminal so as to seat against the rubber gasket at the bottom of the terminal. It is not necessary to have this any tighter than can be set with the fingers. Do not, under any circumstances, use pliers for this purpose.

Correct Order of Firing

The order of firing on the Ford car is 1-2-4-3, in other words, the spark occurs first in cylinder No. 1, No. 2, No. 4 and No. 3 cylinders respectively.

To find the proper connections to the distributor, note: When the distributor cap is replaced on the Unisparker—it will fit only in one position—the terminal to which the distributor block points after the engine is timed properly is always No. 1 and should be connected to spark plug in cylinder No. 1. The next terminal in rotation is No. 2, and should connect to the spark plug in No. 2. The third one connects to cylinder No. 4, and the last one to cylinder No. 3, keeping in mind that the direction of rotation of the distributor is contrary to the hands of a clock.

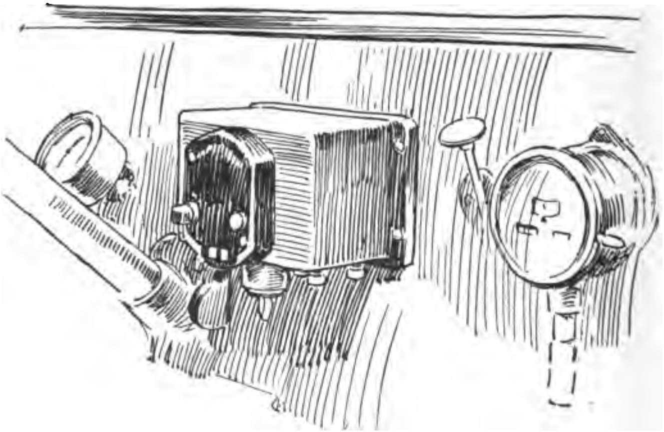


Fig. 136—*Atwater Kent kick switch coil installed on the dash of a Ford car*

The wires leading to cylinders Nos. 3 and 4 should be of sufficient length to run up to the radiator brace rod, to which they should be taped, and then down to their respective cylinders, thus keeping them free from contact with any heated parts of the engine.

Battery Installation

Use six dry cells connected in series. A 6-volt storage battery may be used if desired. The carbon of one cell connects to the zinc of the next, and so on, leaving at one end of the battery a free carbon terminal and at the other a zinc terminal.

On the Ford touring car, the battery can best be located under the rear seat, the cells being installed in a standing position.

On the roadster, the cells are placed in the receptacle back of the gasoline tank and should lie on their sides.

Batteries should be installed so that they are fastened firmly in place and are insulated from each other and from any metal parts on which they might ground.

The pasteboard covering on the dry cells is utterly useless as permanent insulation; therefore, the cells should be separated from each other by wooden or paper wedges, and care should be taken to see that they are not likely to vibrate loose or in any way come in contact with any metal parts of the car.

Battery Wiring and Connections

From the post marked "POS" on the coil run a wire down from the engine side of dash and along frame, up under seat to the point where the battery is installed. This wire should be connected to the carbon post of the battery.

Another wire should run from the post marked "NEG" on the coil in the same manner, and connects to the zinc post on the battery.

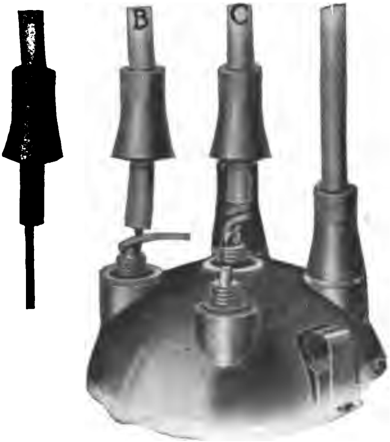


Fig. 137—Method of making connections to distributer

These wires may be fastened with insulated staples to the wooden strips or other wooden parts over which they run. Care should be taken, however, not to drive two staples close together, neglect of this detail being a frequent cause of grounds and short-circuits.

Adjustment of Contact Points

The only adjustable feature of the Atwater Kent system aside from the initial timing is in the contact points. These are adjustable only for natural wear. The initial adjustment made at the factory should be good for several thousand miles of service.

The contact screw is provided with several shim washers against which it is set up tight. When the points eventually become worn, they should be dressed flat and smooth, after which a sufficient number of washers should be removed so that when the contact screw is set up tightly it will maintain the proper gap between the points.

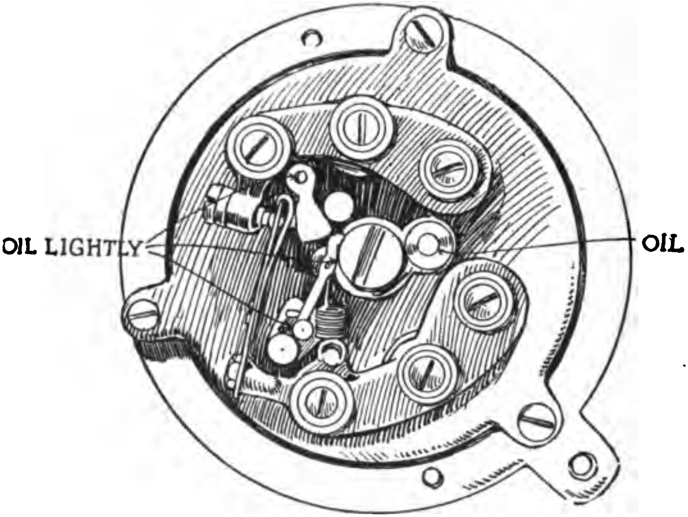


Fig. 138—*Parts of Atwater Kent ignition system that should be oiled*

This distance between the contact points should be the thick-

ness of a thin visiting card, say 0.010 inch to 0.012 inch. They should never touch when at rest.

Precautions in Maintenance

Do not attempt under any condition to alter or change the adjustment of any of the parts of this system. Each part is exactly right in shape. Each spring has the proper tension.

The operation of the contact maker is so rapid that it cannot be followed with the eye, and because you cannot actually see the contact made and broken do not be deceived into thinking that the contact maker is inoperative or that it is defective or worn.

The notched shaft and lifter, also latch which operates the contact spring, are all of glass-hard steel and their movement is so slight that they are subject to practically no wear whatever.

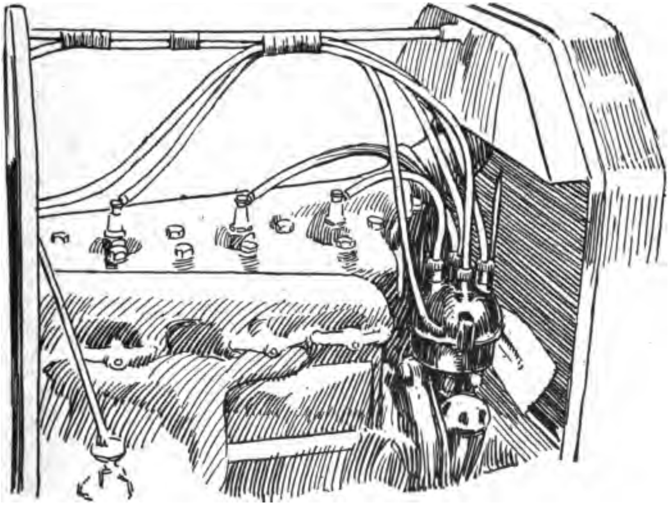


Fig. 139—*Method of supporting high-tension wires in Atwater Kent ignition system*

Oiling

Use a small amount of light lubricating oil on moving parts at intervals of 500 miles. Avoid getting oil on the contact points, Fig. 138.

Locating Trouble

If at any time the engine misses, do not immediately jump to the conclusion that it is due to the spark or the ignition system. There is far greater likelihood that it may be elsewhere.

If missing or falling off in speed is encountered, look first to the valves, note that they are free and seat properly.

1—Note that there is good compression in each cylinder.

2—Look at the carbureter. Make sure it is correctly adjusted and in good order. Note carbureter instructions in Ford manual.

If after looking over the valves and carbureter you are convinced that the trouble is with the spark, proceed as follows:

1—Look over wiring, making sure that all battery and other connections are tight. A loose wire will cause jerking of the car and irregular missing, dropping two or three or more explosions at a time.

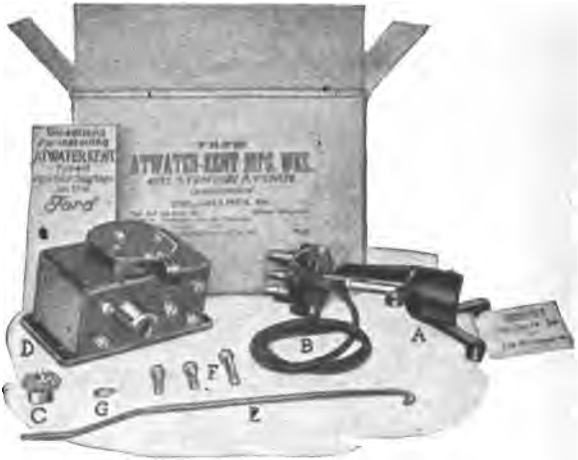


Fig. 140—*Essential parts of the type H Atwater Kent ignition system*

2—Take off one spark plug wire, and note that the spark is at least ¼-inch long. If so, it should be sufficient.

3—Then test batteries, which should show at least 3 to 5 amperes.

4—If batteries are good, examine primary wiring and contact points. If points are too far apart, adjust these, leaving the gap about the thickness of a thin visiting card. Note that the points should never touch when at rest.

5—If spark at the plug wire is ¼-inch or longer, try a new plug first in one cylinder, then in the next and so on until all cylinders have been tested. If this fails to locate the difficulty, examine the secondary wiring between the distributor and plugs. Any plug under suspicion should be replaced with a new one. Simply cleaning will not necessarily restore it.

Type H Atwater Kent Unisparker

The chief difference between the type H and type K-2 system is that type K-2 system is provided with an automatic spark control and the type H system has only the manual control. There is also quite a little difference in the mountings.

The different essential parts of the outfit are shown in Fig. 140 and should include the following:

1—Four-cylinder type H Unisparker mounted on bracket with extended shaft and bevel gear, A.

2—Flexible double conductor cable between Unisparker and coil. This is attached to Unisparker when shipped, B.

3—Bevel-gear pinion, C.

4—Coil complete with switch, D.

5—Four screws for fastening coil to dash.

6—Spark advance rod, E.

7—Three cap screws, F; one lock-washer, G; one cotter pin.

Making the Installation

1—Remove Ford coil box and all ignition wiring.

2—Remove radiator as follows:

  a—Drain off circulating water.

  b—Remove the right headlamp when facing the radiator.

  c—Unbolt upper water connection and loosen hose connection on side of engine, so as to leave both sections of hose connected to the radiator. It is easier to unbolt the water connection flange than to remove and replace the upper hose connection.

  d—Loosen brace-rod check nut at dash and unscrew rod from radiator.

e—Remove nuts from feet of radiator and radiator may be lifted off.

3—Remove commutator by taking off nut, washer and pin, sliding off contact arm and commutator.

4—Remove three bolts from the gear cover marked A, Fig. 140.

5—Place bevel-gear pinion on timer shaft, using lock washer furnished with outfit and nut which held timer in place, 140.

6—Place Unisparker with bracket on front of gear cover, holding it in place by the three extra long bolts, furnished with the outfit, which fit into the holes A, Fig. 140.

7—Do not fasten the outfit tightly in place, but leave it so that the gears can be unmeshed for timing adjustment.

8—Connect the new spark-advance rod provided with outfit between the ball and socket connection on the steering column and the spark advance lug on the Unisparker. This spark advance lug should point directly toward the lever. The spark control lever on steering-wheel should be within three notches of full retard or the upper stop on the sector.

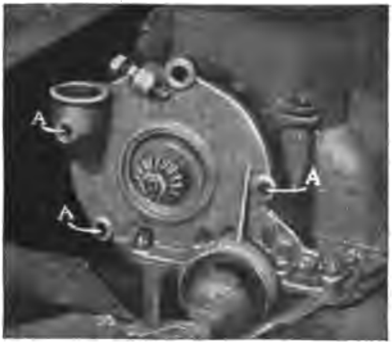


Fig. **141**—***Bevel gear mounted in place of commutator for driving Atwater Kent ignition***

9—Remove the spark plug in cylinder No. 1 next to radiator.

10—Bring the piston in No. 1 cylinder up exactly to high dead center at top of compression stroke.

Timing the Engine

1—Slack off the three bolts holding the Unisparker bracket, so as to leave gears out of mesh.

2—Remove cap of Unisparker, rotate distributor block on top of shaft counter-clockwise until it points to the right at right angles to the engine.

In performing this operation the shaft should be turned very slowly and steadily until a click is heard. The spark produced by the Unisparker occurs simultaneously with this click, and holding the shaft tightly, the bracket should be pushed toward the gear cover to mesh the gears in the exact position at which the click occurred. The three bolts which hold the bracket in position then should be set up tight, thus clamping the Unisparker in position.

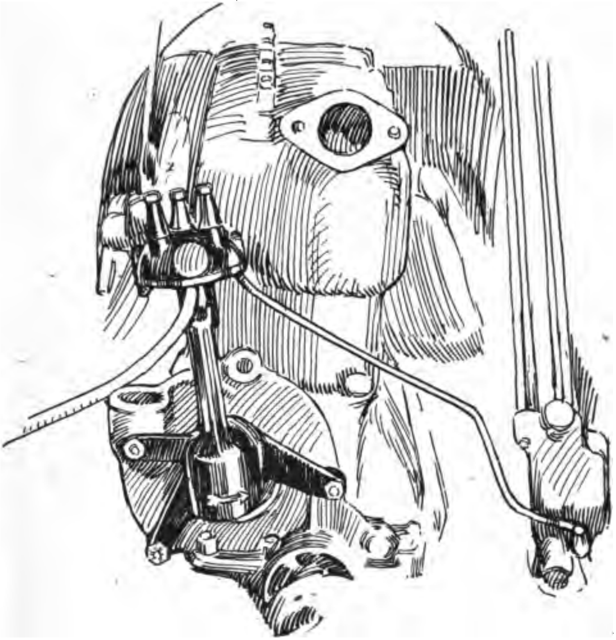


Fig. 142—*Type H Atwater Kent Unisparker bolted in place on Ford engine*

If in meshing the gears the position of the vertical shaft is such that two teeth meet and the gears will not mesh, rotate the vertical shaft back in a clockwise direction just sufficient to enable the teeth of the bevel gears to mesh.

If timed according to these directions, the spark of the Unisparker will occur exactly on center when the spark advance rod is within two or three notches of full retard.

Before proceeding with the wiring, complete mechanical installation thus:

1—Replace the radiator as follows:
  a—Set radiator in position.
  b—Connect upper and lower water couplings. Note that gasket is in good condition.
  c—Bolt radiator in place, taking care not to set up springs under the bolts too tightly.
  d—Replace cotter pins in lock nuts.
  e—Connect brace rod from dash to radiator, screwing it first into radiator and then tightening up lock nut at dash.
2—Replace lamp.
3—Replace spark plug in No. 1 cylinder.

Mount Atwater Kent coil on center of dash so that the round head of the brace rod fits in the space counter-bored for it on the back of the coil. The necessary screws for mounting the coil on the dash are provided with the outfit. After mounting the coil the remainder of the installation is the same as for the type K-2 system and the same instructions may be followed from this point on.

CHAPTER XV

Dixie High-Tension Magneto for Fords

TO prepare the car for installation of the Dixie high-tension magneto for Fords, first remove the hood. Open petcock and drain radiator. Disconnect radiator brace rod and push it back partly through the dash out of the way of future work. Disconnect gas piping, or sockets and lamp wiring, if the machine has electric lighting equipment, leaving lamp parts free.

Next remove the radiator by taking out nuts holding it to the frame and disconnecting the water connections from their clamp couplings at the engine. The next step is to remove the fan and connections. Before starting this it is important to see that the pin holding the fan pulley is in a perpendicular position. This can be done easily now that the crank is on the engine. The pin must be over the hole in the engine base to be in position to be driven through it.

Remove the bolt holding the fan bracket at engine and lift out fan and fan unit. Drive out the pin holding the clutch end of the starting crank and pull away the crank.

With pliers remove the cotter pins holding the fan pulley in position, and with an ordinary punch, drive the pin through the hole in the bottom of the engine base previously mentioned. A smart blow on the pulley will free it from the crankshaft. Now remove the spark advance rod at the steering post and timer. Free timer wires, following their lines to dashboard, where all wires are disconnected and timer and wiring are free from the car. Next remove the eight screws holding the timing gear front plate to the engine and carefully locate the position of each, as they will be used for new plate. See Fig. 143.

Driving Gears and Magneto

Before putting the old plate aside, take felt packing from the crankshaft bearing and camshaft timing gear stud housing. The Dixie high-tension magneto outfit having in the meantime been unboxed, this packing immediately can be replaced correspondingly in the new plate. The various parts of the outfit are shown in Fig. 144.

With the felt packing already referred to fitting snugly in the new housing and bearing, all surfaces thoroughly clean and, preferably a new gasket well shellacked on both sides, proceed by placing the new large driving gear against the face of the timing gear, at the same time being sure that the slotted end of the gear fits over the flat side of the timing gear clamping nut; this acts as a drive for the Splitdorf large gear. Now lock the gear securely with the lock washer and castellated nut furnished; this nut must be screwed on the stud with slots against the gear. Now lock the whole with the cotter pin provided with the outfit.

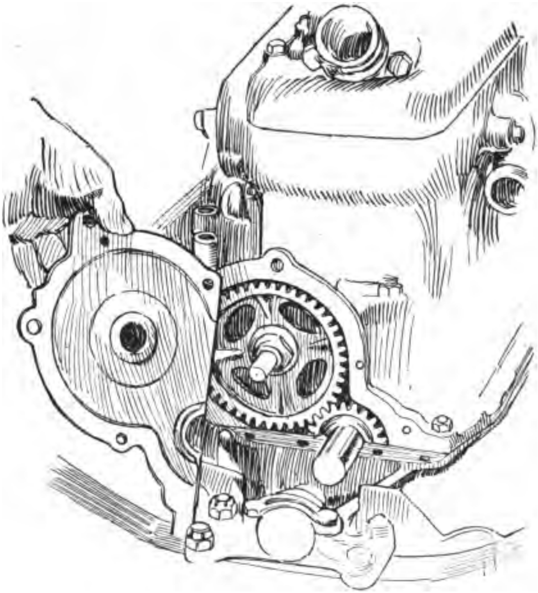


Fig. 143—*The old gearcover must be replaced with the new one shown in Fig.* 144

At this time see that the new gears are greased thoroughly with non-fluid oil. The new plate will be found to line up perfectly.

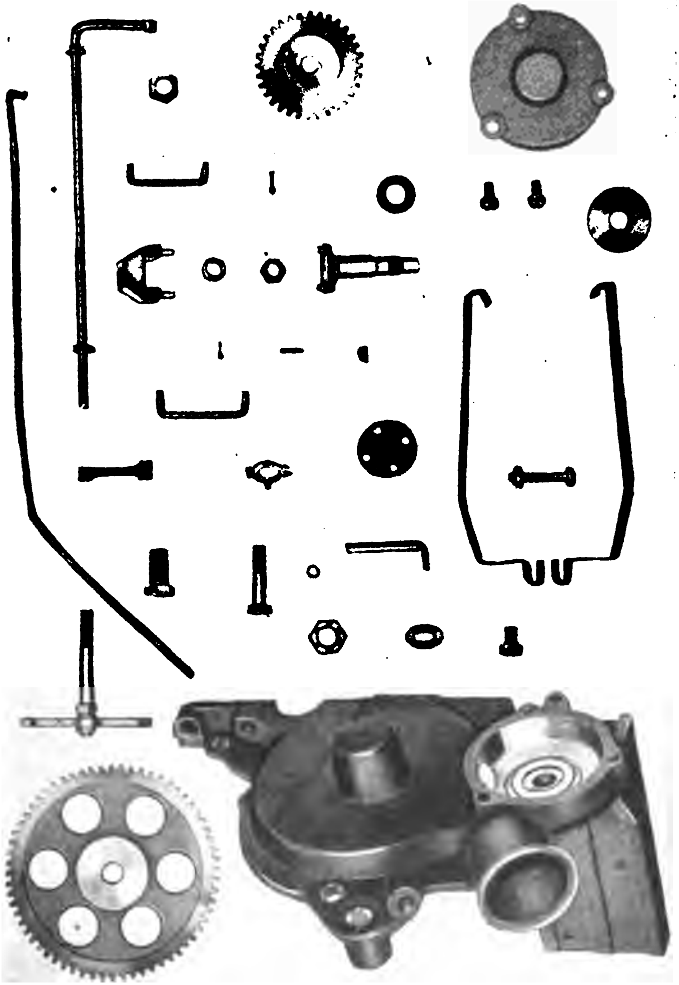


Fig. 144—The various parts required in mounting the Dixie magneto on a Ford car

Start all screws previously removed, including the new screws furnished, into their relative positions, with the exception of the fan screw, and tighten up. Remove the fan belt tightener from the old plate and place it in position in the new housing. Be sure this nut is tight.

Before replacing the magneto on its base the nut holding the magneto coupling should be turned back a few turns to permit the magneto coupling to turn freely on the magneto shaft.

Replace the starting crank and bring the piston of No. 1 cylinder to the top dead center of the compression stroke, place the magneto on its base with the dowel pins in the housing fitting properly in the magneto base and at the same time slide the pins of the coupling into the holes in the leather disk of the other half of the magneto. Now remove the distributor block from the magneto by loosening the thumb nuts and turning the clamps aside.

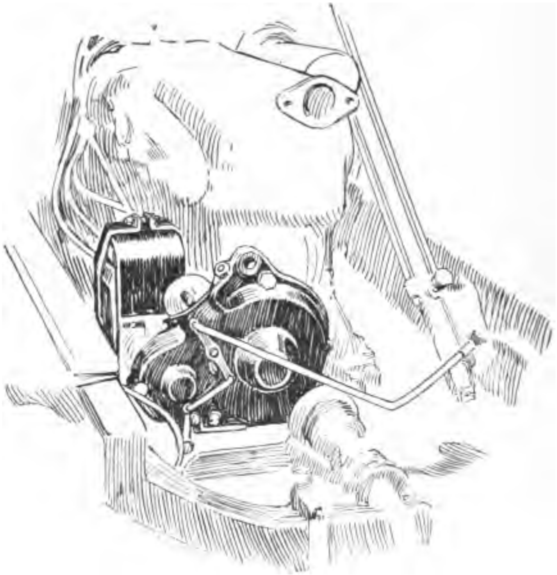


Fig. 145—*Complete installation of the Dixie magneto on a Ford car*

Remove the cover of the breaker, exposing the whole breaker mechanism, and place the timing lever in the fully retarded position. Turn the distributor gear until the platinum points of the breaker are about to separate. In this position drive the coupling on the magneto shaft with a sharp tap. Secure the coupling in position by the nut on the magneto shaft.

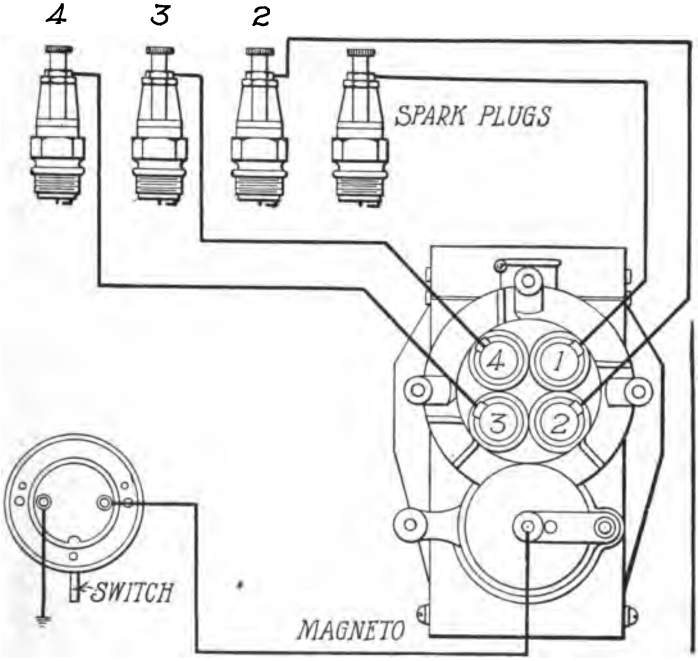


Fig. 146—*Wiring diagram for connecting a Dixie magneto*

After replacing the magneto on its base, secure it in position with the clamps and clamp bolt. The complete installation is shown in Fig. 145.

Wiring the Magneto

The cables leading from the spark plugs to the distributor block must be connected to the distributor block. Note that the firing order of Ford engines, counting the cylinders from the radiator is 1-2-4-3; No. 1 plug firing first, No. 2 second; No. 4 third, and No. 3 fourth.

Connect the cable leading from the spark plug of No. 1 cylinder to the terminal on the distributor block which is in line with the segment on the distributor disk. The cable from the spark plug of the second cylinder should be connected to the next terminal to the left. Connect the spark advance from the lever end of the steering post to the magneto by the long connecting rod to the bell crank on the housing and bell crank link to the brass rod, lever and link to timing on magneto. A bracket intended to hold the cables in position is fastened to the motor.

Now remove the coil box from the dash and all the old ignition wiring connections and use the plate supplied with the outfit to cover the wiring holes. Cut a circular hole in the dash for the Dixie magneto switch convenient to the driver's position. Connect the long wire to the grounding stud on the cover spring of the Dixie magneto, and at "Magneto" on the switch, connect the short wire at "Ground" on switch and steering post mounting on the back of the dash. See wiring diagram, Fig. 146.

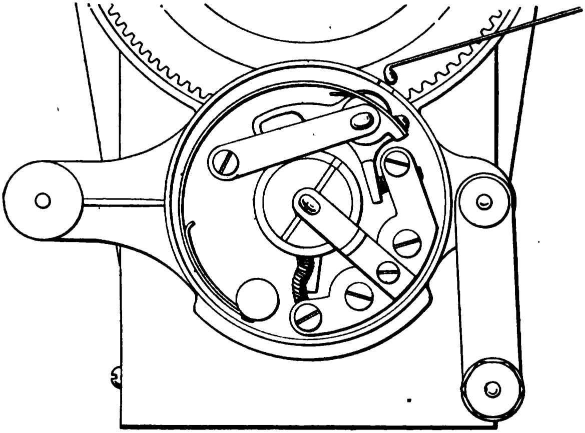


Fig. 147—Interior view of breaker box on Dixie magneto, with cover removed

Replace the radiator and connections. Refill the radiator, examine the spark plugs and set the spark plug points .20 to .25

inch, using the gage on the screwdriver supplied with the outfit for that purpose.

With the switch lever in the magneto position, and the spark lever about a third advanced, crank with a quick snap over the compression. If properly timed the engine should run.

Care of the Dixie

The bearings of the magneto are provided with oil cups, and a few drops of light oil every 1,000 miles are sufficient. The breaker lever should be lubricated every 1,000 miles with a drop of light oil, applied with a toothpick. The proper distance between the platinum points when separated should not exceed .020 or 1/50 inch. A gage of the proper size is attached to the screwdriver furnished with the Dixie. The platinum contacts should be kept clean and properly adjusted. Should the contacts become pitted, a fine file should be used to smooth them to permit them to come into perfect contact. A view of the breaker with the cover removed is shown in Fig. 147.

The distributor block should be removed occasionally and inspected for an accumulation of carbon dust. The face of the distributor disk should be cleaned with a cloth moistened with gasoline and then wiped dry with a clean cloth. Do not pull out the carbon brushes in the distributor because you think there is not enough tension on the small brass springs.

To obtain the most efficient results with the Dixie magneto the normal setting of the spark plug points should not exceed .025 inch and it is advisable to have the gap just right before a spark plug is inserted. The spark plug electrodes may be set easily by the gage attached to the screwdriver furnished with the Dixie magneto. The setting of the spark plug points is an important function which usually is overlooked, with the result that the magneto is blamed when it is not at fault.

Faulty ignition may be due to various causes, and a careful inspection should be made to ascertain whether the spark plugs or magneto require attention.

A spark plug may be short-circuited by a piece of carbon between the electrodes and body of the plug. Removing the carbon particles will remedy this at once.

CHAPTER XVI

Bosch Magnetos for Fords

THE first procedure in installing the gear-driven Bosch magneto on a Ford car includes removing the hood, draining the water from the radiator, removing the coils from the dashboard and loosening the holding nut of the radiator rod at the radiator end. After detaching the water inlet and outlet connections at the engine and disconnecting the priming wire, as well as the gas or electric connections to the headlights, the radiator itself is to be lifted off and the fan assembly and belt removed, leaving the forward end of the engine clear.

Next to be removed are the actuating rod leading from the foot of the steering column to the timer, the bolt and spring holding the timer in place and the timer case with contacts, as well as the wires leading thereto, all of which may be discarded. The hexagon-headed nut, washer and cotter pin holding the timer brush assembly are to be removed and the arm and roller pried off with a screwdriver.

The cotter pin at each end of the crankshaft starting pin, on the inside of the lower fan pulley, is to be withdrawn and the pin itself driven out through the opening in the engine support. The starting handle or crank then is to be removed and the lower fan pulley pried loose by two screwdrivers placed behind it, one on each side. In order that the fan belt may clear the Bosch gear housing, a new fan drive pulley A—see Fig. 148 for parts composing the gear-driven outfit—is to be substituted for the old one and the original crankshaft starting pin, with cotter pin at each end, is to be used to secure it in place. Should the ends of the pin project beyond the rim of the new pulley, they are to be filed down flush. The fan belt and starting crank then are to be replaced.

The key B for the large Bosch gear is to be set in place on the camshaft after first enlarging the hole in the protruding end of the shaft by the $\frac{5}{32}$-inch drill C, furnished with the attachment.

Any burr left by the drill is to be filed down before placing the key in position.

The second and third bolts holding the crankcase on the valve side of the engine are to be removed, also the cylinder front cover tap bolt immediately to the right of the camshaft. The three bolts, two vertical and one horizontal, at the base of the cylinder front cover and to the left of the starting crank, are to be removed and their heads ground down about half way so as not to interfere with the placing of the Bosch gear housing.

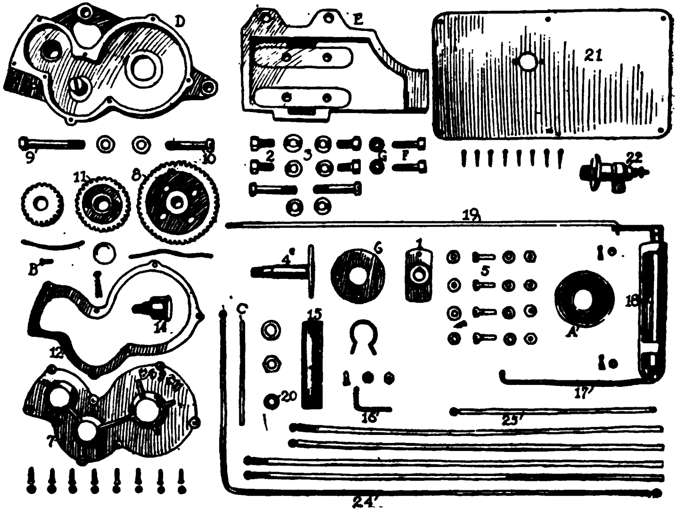


Fig. 148—*Entire gear-driven Bosch outfit for Fords dissembled*

To provide sufficient clearance for the idler section of the Bosch gear housing D, an opening about 2 by 3 inches is to be cut in the engine pan directly beneath the housing, the exact location and size of the opening being determined by applying the housing loosely to the engine, first, however, attaching to the housing the magneto supporting bracket E, using for the purpose the two hexagon-headed cap screws F and washers G. The positions of the four bolts, 2, securing the magneto to its supporting bracket are to be marked off on the engine pan and a hole about one inch square cut at each point so that the magneto may be removed at any time after completion of the installation merely by disconnecting the coupling and withdrawing the four magneto bolts, 2. The cutting of the openings in the pan may be done with hammer and cold chisel and an ordinary jack used to support the pan during the operation.

If these details are executed properly the gear housing and magneto bracket should drop readily into position, Fig. 149. This being assured, the magneto end, 1, of the coupling is to be secured to the magneto shaft by the nut, washer and crescent-shaped Woodruff key accompanying the magneto. The magneto is to be secured to its supporting bracket by the four bolts, 2, with lock washers, 3, and the magneto end, 1, of the coupling is to be connected with the bolt end, 4, of the coupling by the four slotted hexagon-headed bolts, 5, and leather center coupling piece, 6.

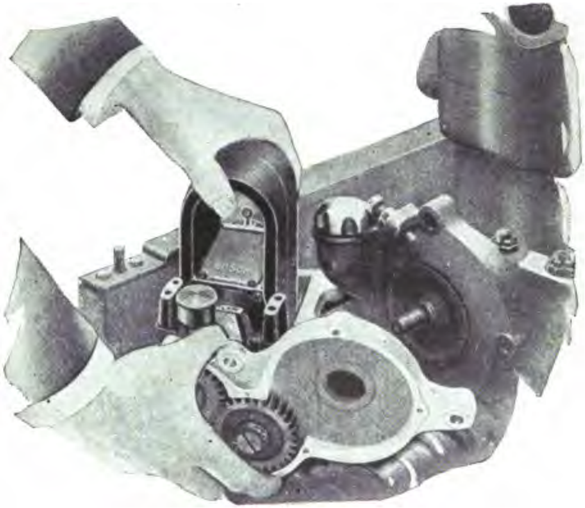


Fig. 149—*Nothing of vital importance to the Ford engine is disturbed in installing attachment*

In assembling the coupling, it should be remembered that the leather center piece, 6, is intended to afford a flexible drive from the gears to the magneto, so as to compensate for any slight irregularities in alignment. To secure the flexible drive effect, however, the two flanges of each coupling end, 4 and 1, must be bolted directly to the leather center piece at right angles to each other or, in other words, the flanged ends must be set crosswise one to the other, using all four bolts provided for the purpose. Under no circumstances should the flanges of the two coupling ends be bolted directly together, that is, in a straight line using only two bolts, as such an arrangement would give a rigid, not a flexible, drive.

The Bosch gear housing cover, 7, and large gear, 8, then are to be removed and the entire attachment mounted on the engine and held loosely by the four supporting bolts, one 9 and one 10, for the gear housing and two, 10, for the magneto bracket, the former two being partially tightened.

It is possible that slight inequalities in the engine casting may interfere with the proper alignment of the Bosch outfit, so that special care is to be taken that both lugs of the magneto bracket, E, bear on the flange of the crankcase and that the two holes in the bracket lugs register with those in the crankcase flange. Any irregularities which exist may be corrected readily by slightly filing the face of the Ford oil cup casting, or the shoulder of the Bosch gear housing resting thereon, or by placing washers under both lugs of the magneto bracket.

Timing the Magneto

The dust cover over the magneto armature, also the slipring brush holder farthest from the engine, are to be removed now and the piston of No. 1 cylinder, that nearest the radiator, brought on top dead center of the compression stroke and maintained so. The magneto armature is to be turned by hand by its coupling in the direction in which it is to be driven until, first, the metal slipring segment is visible in the slipring groove corresponding to the figure "1" of the brush holder which has been removed and, second, the trailing end of the armature is about $\frac{9}{16}$ inch from the pole shoe on the right side of the magneto, viewed from the shaft end. The $\frac{9}{16}$-inch distance should be measured as shown by the letter "E" in Fig. 150. With the armature held in this position, the large gear, 8, is to be slipped into place on the camshaft and meshed with idler gear, 11, care being taken to see that the piston of No. 1 cylinder has not moved from the top dead center position.

It is important that the gears should not mesh too tightly and, after tightening both bolts supporting the housing, it should be seen that there is approximately the same play between the large gear and the idler gear as between the idler and the small magneto gear. In case the large gear meshes too tightly the two bolts supporting the gear housing again should be loosened and the entire housing shifted slightly to the left, which may be done quite readily as the two bolt holes in the gear housing are a trifle oversize. In like manner, the housing should be shifted slightly to the right in case it is found that the gears 8 and 11 mesh too loosely.

With the adjustment of the gears correct, the two gear housing supporting bolts, as well as the two bolts securing the magneto bracket to the crankcase, are to be permanently tightened, using for the two bracket bolts the original Ford nuts, and new lock washers, 3. The original nut and washer also are used on the end of the camshaft to retain the large gear, 8. The gear housing, D, is to be packed with a good quality grease or non-fluid oil and, after carefully fitting the paper gasket 12, the gear housing cover 7 is to be secured in place. During operation, the grease cup, 14, of the Bosch gear housing should be given a turn every day and the cup itself filled with grease whenever oil is supplied to the oil cup on the Ford cylinder front cover.

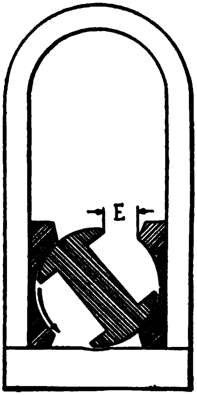


Fig. 150 — Where the measurement E is taken

Cable Connections

The slipring brush holder and the dust cover over the magneto armature are to be replaced and the four high-tension cables connected as follows:

The cable marked "1" in the brush holder farthest from the engine is to be connected to No. 1 cylinder, while the cable marked "2" in the same brush holder is to be connected to No. 2 cylinder. The cable marked "1" in the brush holder nearest the engine is to be connected to No. 4 cylinder, while the cable marked "2" in the same brush holder is to be connected to No. 3 cylinder. See Fig. 151.

The firing order of the Ford engine is 1-2-4-3. All cables are to be led under the arch of the magneto magnets and through cable guide 15, supported by bracket 16, the latter being secured to the engine by the middle cylinder head bolt on the magneto side. See Fig. 152.

Completing Installation

After engaging the short connecting rod, 17, with the arm of the interrupter housing and securing it in place by washer and cotter pin, the advance bracket, 18, is to be set across the first two studs holding the inlet and exhaust pipe clamps and is to be secured to the clamp with the original nuts. If necessary, the shoulders of both clamps are to be filed down to permit the nuts to fasten properly on the studs. The long connecting rod, 19, passing across the front of the engine, is to be engaged with the ball joint of the foot of the steering column to which the timer rod originally was connected.

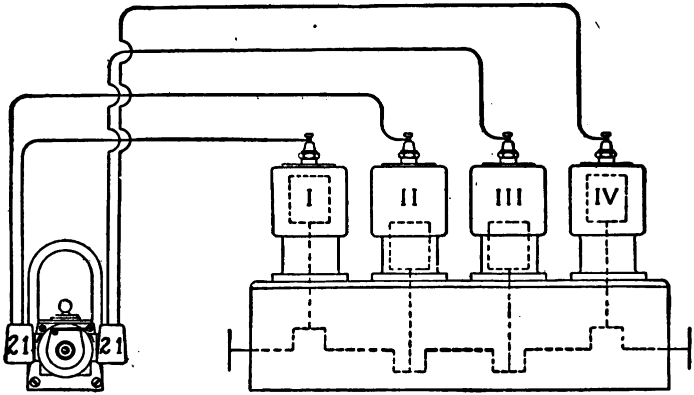


Fig. 151—*Wiring diagram of DU4 magneto for gear-driven Bosch attachment for Fords*

The fan, pulley assembly and belt are to be replaced in their former position, after first placing spacing washer 20 in back of the driven fan pulley to align it with pulley, A, on the crankshaft. See Fig. 153.

The face of the hole in the dashboard through which the radiator rod passes is to be slightly countersunk to receive the head of the rod and permit metal plate 21 to set snugly against the dash, covering the holes left by the coil box. The Bosch key switch 22 also is to be fitted and connected.

In view of refinements incorporated in the later Ford models, the Bosch installations on such models differ slightly from those on the earlier models. The points of difference are two, namely, a metal dash plate, with a curve cut out of the lower edge, is supplied in place of the dash plate used on earlier models and is secured to the dash by the four bolts used for securing the coil. The other point is that the original cable between the terminal on the Ford magneto and the coil, also the cable between coil and lighting switch, is to be discarded, and a new low-tension cable is to be connected directly between the generator and lighting

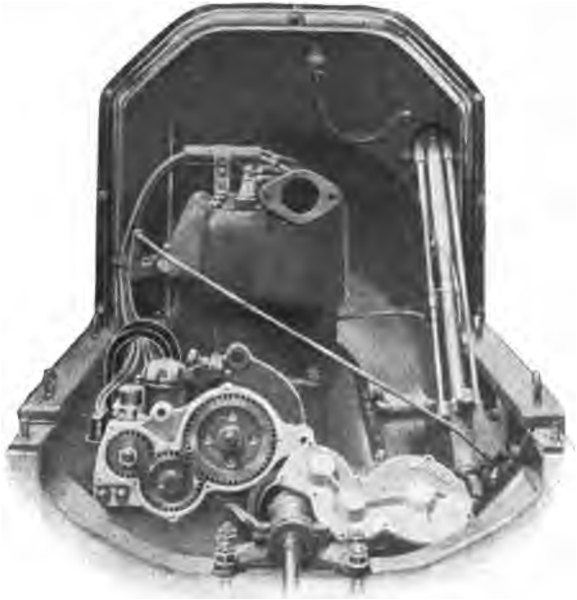


Fig. 152—*Attachment in place with cables connected and gearcover ready to be placed* switch, the terminal end being attached to the flywheel generator and the other end to the lighting switch.

The radiator is to be returned to place and all bolts securing it and its water inlet and outlet connections tightened up, first, however, applying a coat of shellac or white lead to the gaskets between the water connections and the engine. After refilling the radiator the engine may be started and tested and, if O. K., the connections to the headlights are to be replaced.

During the engine test, the operation of the gears especially should be noted. If during operation the gears give rise to a high pitched ring, the indications are that they have been meshed too tightly, while a rattling noise indicates gears meshed too loosely. Either condition should not be allowed to continue but should be corrected in accordance with the instructions under the heading Timing the Magneto.

Under proper conditions the engine can be started on the magneto with the spark fully retarded, but when the magneto is set according to the instructions the spark lever may be safely advanced about half and in this position will permit easier starting. The proper gap between electrodes of spark plugs on Ford machines is $\frac{1}{32}$ inch and it should be seen that the gaps are maintained thus to insure the best operating results.

The timing arrangement suggested results in ignition taking place when the piston is at top dead center of its compression, or working, stroke, the spark lever being fully retarded. With this setting the best results are obtained on a Ford car, making it possible for the engine to idle down to especially low speed and at the same time permitting the development of maximum power at both high and low engine speeds.

Bosch Key Switch

To permit the cutting off of the ignition and locking it, the Bosch key switch is provided with the outfit, and is attached to the dashboard after the metal plate has been secured in place.

The long low-tension wire, 24, is attached to the grounding terminal on the cover of the magneto interrupter housing and brought through cable guide 15 to the thumb screw at the end of the switch barrel. The short low-tension wire, 25, is led from the thumb screw on the collor clamp of the switch and attached to one of the bolts of the steering gear. When the switch button or key is turned a quarter turn to the right or left, the primary is not grounded and the magneto produces current. To cut off the ignition, the switch button or key is turned in the opposite direction until released, when the primary current is grounded and the magneto is made inoperative.

Chain-Driven Bosch Magneto

In the installation of the chain-driven outfit the preliminary work from removal of the radiator to removal of the timer is the same as with the gear-driven outfit.

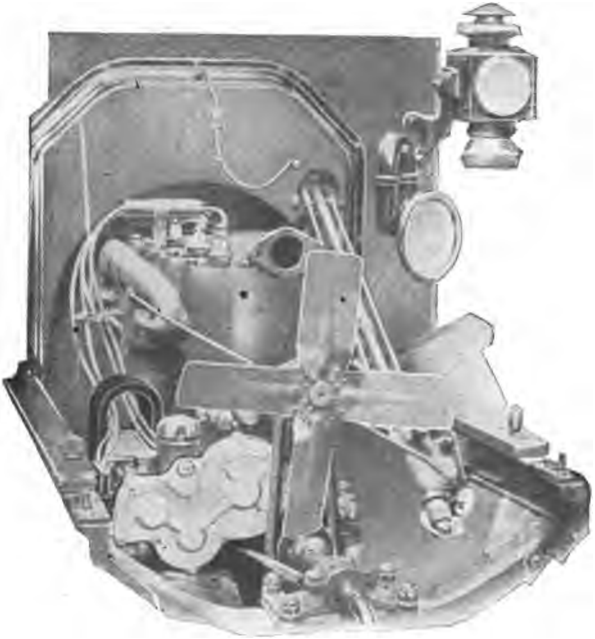


Fig. 153—*Complete installation of Bosch magneto on Ford engine*

Proceeding further, the second and fourth bolts holding the crankcase at the right side of the engine, viewed from in front of the car, are to be removed and the magneto bracket, A, Fig. 154, placed in position, bolts B holding the bracket at its base and the bolt C holding the extension support or arm to the rear of the casting to which the cylinder front cover is secured. The bolt C takes the place of the fan bracket bolt.

It is possible that the face of the casting to which the extension support of the Bosch bracket is to be fastened may be rough and uneven. If so, a few rubs with a file will provide a solid and smooth fit for the face of the bracket.

Driving gear D is to be keyed to the camshaft by the special key B, Fig. 148, first, however, enlarging the hole in the end of the shaft by the $\frac{5}{32}$-inch drill C, as in the gear-driven installation. The hexagon nut and washer used originally to secure the timer brush assembly are to be employed to hold the gear to its shaft.

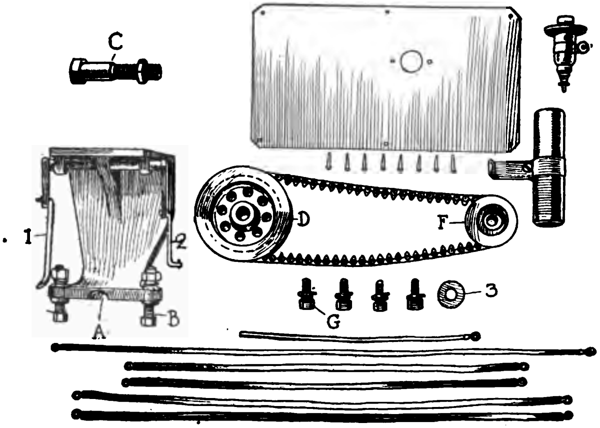


Fig. 154—The parts of the Bosch chain-driven attachment

The hexagon-headed tap bolt holding the cylinder front cover immediately to the right of the camshaft should have its head ground down, leaving it $\frac{1}{8}$-inch thick. Part of the projecting rib of the cylinder front cover directly behind the starting handle, also the lug on the bottom of the fan bracket, should be filed away so as to leave proper clearance for the magneto driving chain.

The small gear F, Fig. 154, is to be secured to the magneto shaft by the nut, washer and crescent-shaped Woodruff key accompanying the magneto. The magneto then is to be set upon the bracket A and, after timing it to the engine as with the gear-driven outfit, the chain is to be slipped into place over the gears D and F, the four holding bolts G being employed to secure the magneto in position.

Care should be taken that the magneto is set parallel with the camshaft and that the two drive gears, D and F, are aligned properly.

The instructions for connecting the cables of the gear-driven attachment apply also to the chain-driven attachment, but it should be noted that, as the magneto locations in the two installations are different, the wiring for the chain-driven outfit, when completed, will differ somewhat from the other, that is, the right brush holder, instead of the left, will be connected to cylinders Nos. 1 and 2, while the left brush holder, instead of the right, will be connected to cylinders Nos. 3 and 4.

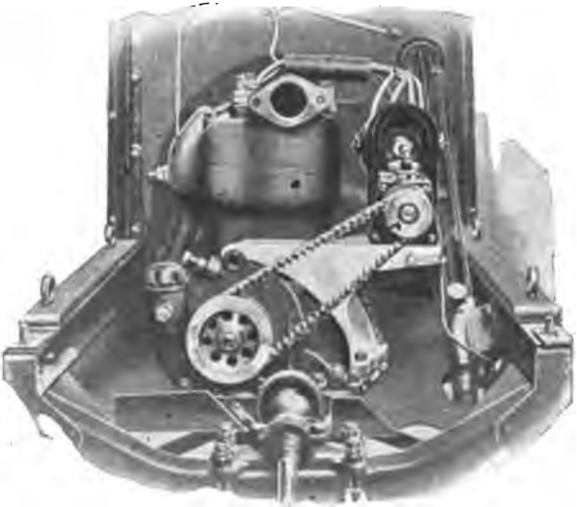


Fig. 155—*Bosch attachment for Fords with chain drive*

The fitting of the metal plate and key switch is to be carried out in the same manner as in the gear-driven installation. In connecting the timing rods, 1 and 2, the former is to be engaged with the ball joint of the spark advance mechanism at the foot of the steering column and the latter engaged with the arm of the magneto interrupter housing.

Washer 3 is to be placed in back of the driven fan pulley to set it forward so that there will be more clearance for the fan belt, after which all that remains is to replace the fan assembly, radiator, etc., as in the gear-driven installation and the work is complete. See Fig. 155.

In conclusion, it should be noted that the remarks relating to the starting of the engine, timing arrangement and proper spark plug gap apply also to the chain-driven Bosch Ford attachment.

CHAPTER XVII

Vibrator-Les Ignition for Fords

AN ignition system eliminating the vibrating type of coil and conventional timer is made by the New York Coil Co., New York. One of its many advantages is that a rapid and positive interruption of the primary current is obtained without sacrificing the possibility of thoroughly saturating the primary windings of the coil. The coil is of the non-vibrating type, is specially wound to obtain thorough saturation of the primary circuit and eliminates the regular Ford dash unit, which is replaced by a neat panel containing a two-point switch. The new coil is supported by a special bracket which is attached or bolted to the studs of the intake manifold.

Interruption Is Positive

The device producing the break or interruption of the primary circuit, which is mounted on an elevating gear bracket, is shown in Fig. 156. It is a simple apparatus, one that is practically foolproof, and a construction that requires no attention other than an occasional adjustment of the contact points. The operation of the breaker is novel, as it combines magnetic and mechanical action, one checking the other, and the possibility of the points fusing or sticking is eliminated. This is an advantage, particularly when the engine is started by manual cranking.

How Breaker Is Made

The breaker includes an armature, D, carrying a contact point, H, Fig. 156. Directly under the armature is a magnet, E, connected in series with the primary winding of the non-vibrating coil. The member C is supported at one end by a stiff spring arranged normally to exert a downward pressure to keep the contact points separated. The part C also engages a hooked section of the armature, further assuring normal separation of the contact points.

Breaking the Circuit

The closing of the circuit, or engagement of the contact points, is obtained when one of the four steel pins of the rotating member B contacts with the member C. This raises the member C and allows the armature D with its point to contact with the fixed point L, which is in the form of a screw. This screw is carried in a support, and the former is slotted so that it is a simple matter to make any required adjustments.

The circuit is completed through the magnet E when the contact points meet, and the magnet is so energized and the circuit so rapidly established and broken that a shower of sparks is obtained from the secondary of the coil. This action continues during the time the pin makes mechanical contact with the member C. After the pin separates the armature assumes the position shown in the illustration, thus breaking the primary circuit and preventing fusing or sticking of the points as previously explained.

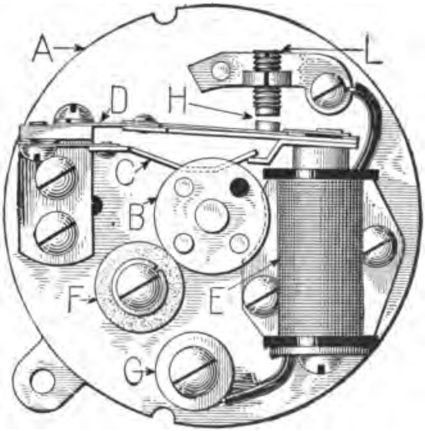


Fig. 156—*Top view showing how Vibrator-Les coil of New York Coil Co. operates*

The Vibrator-Les system comes complete with all wires, cables with terminals, also a tube for supporting the high-tension leads.

Installing the System

The timer on the engine is removed and by taking off the nut and prying off the small collar, a pin will be found which should be pushed or driven out and then by means of a screwdriver the part carrying the roller and the spring of the old timer can be pried off the shaft. The loose gear accompanying the new bracket is slipped on the shaft, the same pin and collar being used to fasten the gear to the shaft. The nut should be tightened securely.

The bolt located directly under the oil filler, which holds the end plate to the crankcase, is removed, as is likewise the bolt on the opposite side. The bracket then is placed in position, having first loosened the upper bolt that tightens the fan belt. See that the bracket fits inside the central turned out surface of the end plate and by two longer bolts furnished with the outfit secure the bracket in position. Care must be exercised to see that the brackets fit properly in the turned out section. Due to some variation present in the end plates it may be necessary in some cases to fit a washer between the lugs of the bracket arms and the end plate.

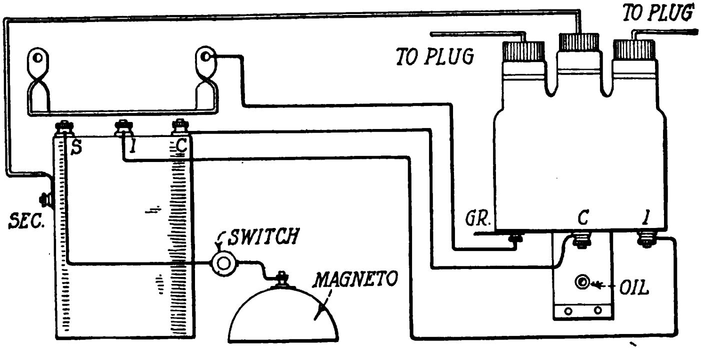


Fig. 157—*Wiring diagram of Vibrator-Les ignition system for Fords*

Extreme care must be exercised to draw up evenly on the bolts and see that the bracket fits readily into position. If the bracket will not go easily into position, the lugs are likely to be broken off by careless handling. The bracket should be filled with soft grease.

Timing the Instrument

Disconnect the spark plug cables and remove spark plug No. 1. By No. 1 is meant the plug next to the radiator. Lay it on the engine with the cable connected to the coil and have the spark lever on the steering post all the way forward or in the retarded position. Turn the engine carefully until a spark takes place at No. 1 plug. Be very careful to stop the engine the instant the coil begins to vibrate. This method is a simple way of ascertaining the proper firing position for those not skilled in timing the engine.

A much more positive procedure is to have an assistant turn the engine until both valves are closed, then by looking into the spark plug hole the next half turn of the crankshaft will bring the piston to the extreme upward travel of its stroke. It is in this position that the spark should take place in No. 1 cylinder, which may be accomplished by turning the shaft of the distributer in a counter clockwise direction by the two set screws, until a spark will jump ¼ in. from the end of No. 1 terminal to the metal part of the engine. Of course, it is understood that the new advance rod has replaced your old one, that the spark advance lever under the steering wheel is in the extreme forward position and that the wiring is all connected. A battery should be used as a source of current in making these tests. Care should be taken to tighten the set screws in this position, which completes the setting of the instrument.

Wiring the System

The wiring is to be exactly as shown in Fig. 157. Of course, it is understood that the regular Ford coil box is removed and the panel supplied containing the switch has been secured in its place. The long wire attached to the switch is run through a hole registering in the dash and carried completely through the metal tube, down to the coil and connected to the coil post marked S. The magneto cable is connected to the very short wire which is run through the opposite hole on the dash, connection being made by putting the looped end of the wire under the screw head and nut on the magneto terminal. One primary wire from the bottom of the distributer terminal on which is stamped I must be connected to the center post on the coil marked I. The other primary wire from the bottom of the distributer has the terminal marked

C and must be connected to the post C on the coil. The third wire coming from the bottom of the distributer has its terminal marked G. This is clamped under the coil bracket between the bracket and the manifold to insure a good ground connection. The secondary wire from the center of the distributer is connected to the post on the left side of the coil.

The plug terminals are brought out through the metal carrying tube in the proper order and are connected in direct rotation to the plugs as marked, which is 1—2—4—3. Proper firing order will result, as the plugs are connected to the distributer in such a manner that the spark will occur in the various cylinders in the order of 1—2—4—3, which is correct for the Ford engine. Do not become confused on this point.

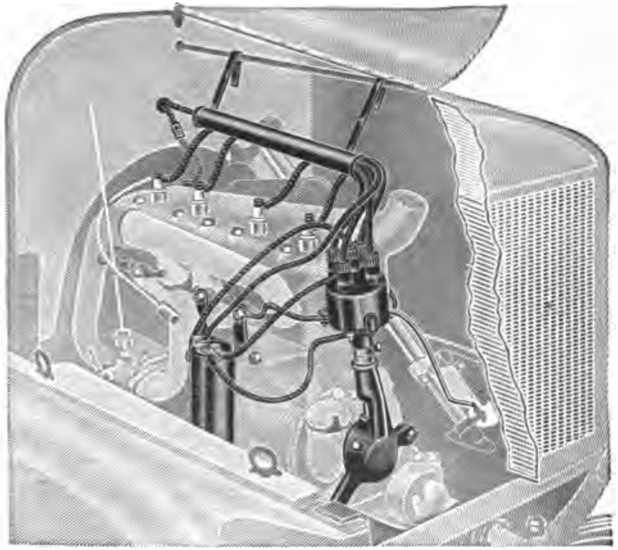


Fig. 158—Complete installation of New York Coil Co.'s Vibrator-Les ignition system on a Ford

The coil is secured by removing the nuts from the two studs holding the manifold to the engine, nearest the radiator. The coil brackets are slipped over the studs and the nuts are replaced, with the ground wire under the forward clamp. The switch is on when the bottom of the key points toward No. 1 point on the switch.

If it should ever be desired to use dry cells or storage battery in connection with the magneto, a wire direct from the battery is carried through the dash and by removing the switch cover connection may be made under the screw head to the bottom lug on the right side of the switch. The other side of the battery is connected to the frame of car. The complete installation is shown in Fig. 158.

Adjustments

The instruments are adjusted carefully before leaving the factory, and it should never be necessary to change the tension of the vibrator spring unless a new vibrator is necessary. All adjustments should be made by the single adjusting screw and should be such that when engine is turned so that one of the pins raises the curved member to its full limit there should be a space between the contact points the thickness of two sheets of writing paper when the armature is held against the magnet by the finger.

It is of great importance that the tension on the armature spring is neither too weak nor too stiff. This tension may be regulated by loosening both the screws holding the bracket to the base that supports the armature. However, this should never be attempted unless the spring's tension is too great to allow the armature to vibrate at low speed or too weak to give a sufficiently powerful spark.

Several drops of oil should be injected into the oil cup twice a week. However, do not over-oil, as any oil on the contact points will cause missing.

CHAPTER XVIII

Philbrin Ignition for Fords

THE Philbrin ignition system for Ford cars is of the open-circuit type, and it is so constructed that it may be operated by current from the Ford magneto or from a battery. Instead of a single spark being delivered to each spark plug in its firing order, a continuous shower of sparks of high intensity is delivered to each plug at the proper time. This flow of sparks is produced by a special high-frequency interrupter which is mounted in the switch case.

An interior view of the distributor for this system is shown in Fig. 159 and it is arranged to be mounted on the front end of the

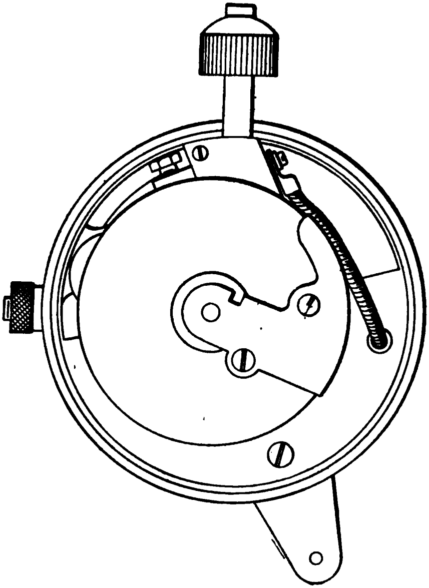


Fig. 159—*Interior view of Philbrin distributor*

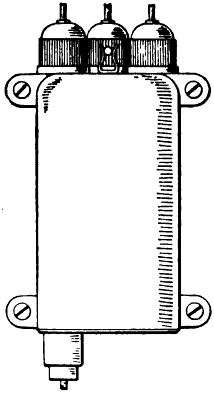


Fig. 160—*Philbrin non-vibrating ignition coil*

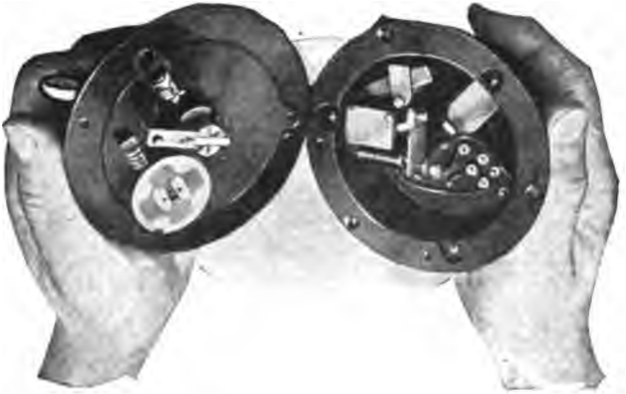


Fig. 161—*Interior view of Philbrin switch case, showing high-frequency interrupter and condenser*

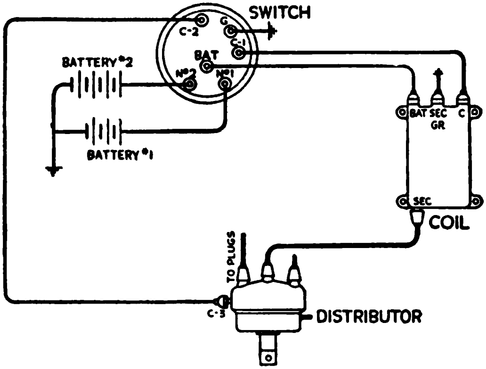


Fig. 162—*Wiring diagram of Philbrin duplex ignition system*

Ford engine and driven at half engine speed. The induction coil is of the non-vibrating type shown in Fig. 160. An interior view of the switch case which shows the condenser and high frequency interrupter is shown in Fig. 161. A wiring diagram of the system is shown in Fig. 162.

CHAPTER XIX

Auto-Lite Electrical Starting and Lighting Systems

THE early models of Auto-Lite generators were of the permanent-magnet field type, three sets of tungsten steel horseshoe magnets being used to produce the magnetic field, as shown in Fig. 163. The armature was made to revolve in the field produced by the permanent magnets by having the armature shaft connected indirectly to the driving shaft by a friction clutch. The driving and driven members of this friction clutch are held in place by springs whose pressure is controlled by the centrifugal force produced by the rotation of two swinging arms. At an armature speed of approximately 1850 revolutions per minute these arms are revolving swiftly enough to compress the springs which hold the clutch members in contact with each other and thus allow the sprocket, which is being driven by the engine, to revolve independent of the armature shaft of the generator.

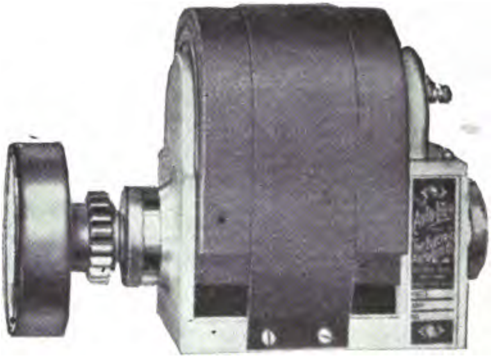


Fig. 163—*Model C-60 Auto-Lite generator*

By this arrangement the armature speed is maintained at about 1850 revolutions per minute no matter how fast the engine may be rotating so long as it is at a sufficient speed to produce 1850 revolutions per minute of the generator. The speed of the generator is about two and a half times that of the engine. It is driven by a silent chain from the crankshaft or any other shaft rotating at the same speed, and its action is entirely automatic. The output of the generator is under normal conditions approximately 12 amperes. This type of Auto-Lite generator is known as the model C.

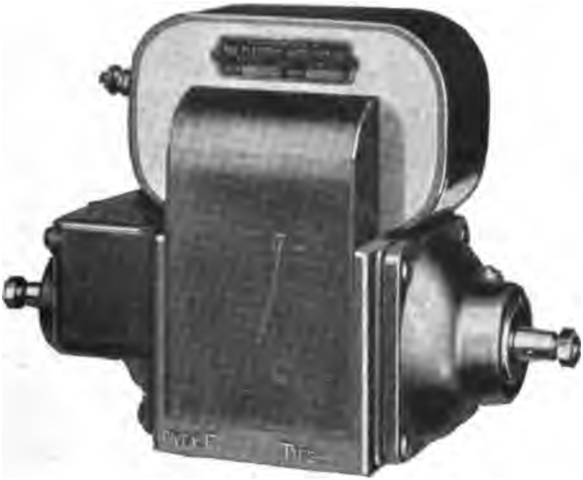


Fig. 164—Model GF Auto-Lite generator

A second type of Auto-Lite generator is shown in Fig. 164. It will be observed that this machine is of the excited field type. The chief differences between this generator and the permanent-magnet type lie in the method of producing the magnetic field and the fact that the armature revolves at the same speed as the crankshaft in the case of four-cylinder engines and one and a half times crankshaft speed in the case of six-cylinder engines. The fact that this generator is designed to be driven at such high speeds, combined with the additional fact that its base has magneto dimensions, is of immense advantage in installation, as the generator can be placed on the bracket provided on the engine for the magneto and driven directly by the magneto shaft. The magneto can be placed back of the generator and driven through it, as both ends of the generator shaft are given the same standard taper used on all magneto shafts.

Two field windings are provided. One is composed of many turns of small wire and is called the shunt winding, while the other is composed of comparatively few turns of large wire and is called the series winding. The shunt winding has a current produced in it which is proportional to the terminal voltage of the generator, since the resistance of the shunt winding remains practically constant. The current delivered by the generator passes through the series winding, since it is connected directly in series. The current in the series winding flows around the magnetic circuit of the generator in the opposite direction to the current in the shunt winding, and as a result their magnetizing actions oppose each other rather than assisting each other. As the current output of the generator increases there is an increase in the magnetizing action of the series field, and as a result there is a decrease in the strength of the magnetic field of the generator and, hence, the output of the generator does not increase

Fig. 165—*Model GD Auto-Lite generator* as rapidly as it would if there were no weakening effect on the magnetic field due to the action of the series field. The voltage of the generator at approximately 6 miles per hour is such that it starts delivering current and the current output increases in value until a speed of about 20 miles per hour is reached when the current output is in the neighborhood of 12 amperes. Auto-Lite generator models G, GA and GF all are provided with one series and one shunt field coil.

An external view of a third type of Auto-Lite generator similar to the ones just described but having two shunt and two series field coils is shown in Fig. 165. This machine is designed to operate at twice engine speed. It starts delivering current at about 7 miles per hour, and at a speed of about 20 miles per hour it delivers approximately 12 amperes. Auto-Lite generator models GB, GC, GD and GG all are provided with two shunt and two series field coils.

A fourth type of Auto-Lite generator having only two shunt field coils is shown in Fig. 166. The output of this generator is regulated by the third-brush method. It operates at one and a half engine speed, cuts in at about 7 miles per hour, and delivers approximately 14 amperes at 20 miles per hour.

Motors

The following brief description of the starting motor will apply to all types of starting motors manufactured by the Auto-Lite company. The frame is provided with four pole-pieces and four field coils. The brush holder assembly consists of four brush holders stamped out of sheet steel and then copper plated to prevent rusting. The brush holders are assembled on the head of the motor with studs or bolts that go through the brush holder and spring, through the head, and are held by a lock washer and unit. The stud is insulated with a fiber washer, a fiber brushing in the head and a fiber washer on the outside. This gives a strong assembly free from mechanical or electrical trouble. The first coil of the field winding is connected to the positive terminal, or insulated terminal on the motor frame. The other side of coil No. 1 is connected to one side of coil No. 2, and the remaining side of coil No. 2 is connected with the brush holders on opposite sides of the commutator through a heavy braided flexible wire. Coil No. 3 is connected to the remaining two opposite brush holders, and the other side of the coil is connected to one terminal of coil No. 4, and the remaining terminal of coil No. 4 is connected to the negative terminal, or grounded terminal, on the motor frame. The armature is wound with heavy wire that is held in place by bands around each end of the winding.

The Bendix drive is used with all the starting motors as a means of establishing the mechanical connection between the motor and engine when the motor is called upon to start the engine. Two different types of Auto-Lite starting motors are shown in Figs. 167 and 168.

Cutouts

An electromagnetic cutout is used in establishing the connection between the generator and the storage battery when the voltage of the generator has reached a value equal to or preferably a little greater than the terminal voltage of the battery. This connection will remain closed as long as the generator continues to supply current to the battery or lamps, but just as soon as the battery starts to send current back through the generator, which causes the generator to operate as a motor, the cutout, if operating properly, will open the circuit and thus prevent an un-

Fig. 166—*Model GH Auto-Lite generator* necessary discharge of the battery. The armature of the cutout never should be moved when the generator is not running, as the action of the cutout under these conditions is such that it will keep the circuit between the generator and battery closed in spite of the fact that the battery is discharging, and the result will be a discharged battery and perhaps a damaged generator. If the armature of the cutout is accidentally or otherwise drawn up and the circuit thus closed, the armature should be pried away from the iron core and the circuit opened, or the engine should be started and run at such a speed that the voltage generated in the generator will be ample to counteract the voltage of the battery.

Starting Switches

The starting switch most commonly used consists of a metal ring with several extended arms, or leaves, which extend parallel to the axis of the ring. A cylindrical copper sleeve slides on a vertical rod and may be pressed inside the extended arms on the ring by a foot button. The ring forms one terminal of the starting-motor circuit, and the cylindrical copper sleeve forms the other terminal, so that the starting-motor circuit is closed when these two parts of the switch are in electrical contact with each other. As soon as the pressure on the foot pedal is removed the switch immediately is opened by the action of a strong spring.

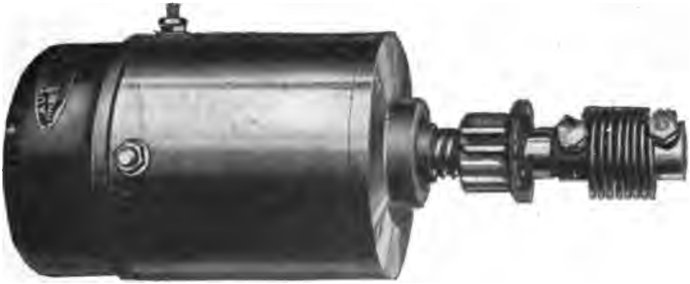


Fig. 167—Model MD Auto-Lite starting motor

A second type of starting switch operated directly by applying a pressure on a push button consists of two heavy copper strips set opposite each other with their flat sides parallel. These two strips form the terminals of the starting circuit. A copper bar is mounted on an insulating block which slides on a rod in such a manner that the copper bar connects the two strips when the block is pressed down by the driver's foot button. The copper bar and block upon which it is mounted are returned to the off position, that is, the switch is opened, by a coil spring mounted on the shaft upon which the block is mounted.

Another type is mounted on the starting motor housing and is operated by rods running from a foot pedal or hand lever. The switch consists of two flat copper contact arms brought into electrical contact with each other by a bar of copper mounted on an insulating block, which in turn is carried on a sliding rod directly beneath and parallel to the copper contact arms. The starting switch is closed by the same operation on the part of the driver that moves the sliding pinion into mesh between the starting motor pinion and the flywheel gear. On some models an additional housing is provided on the starting motor case, and it carries a solenoid and plunger core. The plunger of this solenoid normally drops down into position so that it prevents the closing of the starting motor switch or the meshing of the gears should the driver intentionally or otherwise attempt to start the motor. When, however, the solenoid is energized, the plunger is moved and no longer offers an obstruction to the movement of the rod operating the starting motor switch. A special

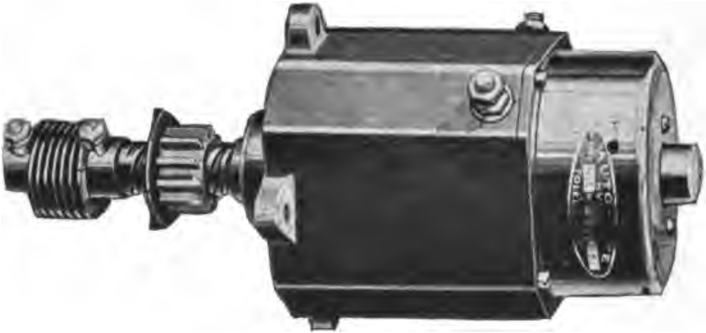


Fig. 168—Model MF Auto-Lite starting motor

switch is provided for closing the circuit through the solenoid winding and this switch must be closed when the driver attempts to start the car.

The Ammeter

The ammeter, which is mounted on the dash in plain view of the driver, indicates at all times the amount of current being produced by the generator or discharged from the battery, with the exception of the starting motor and ignition current.

When the indicating needle of the ammeter points to the left of the zero point on the scale, or toward "discharge," it means that the battery is furnishing current to the lights, or discharging. When the needle is pointed to the right of zero, it means that the generator is delivering current to the battery, or charging it. The amount of charge or discharge at any time in amperes can be read from the scale on the ammeter. The ammeter does not show the amount of energy in ampere-hours in the battery.

Always note the position of the indicating needle when the engine is stopped. With the engine at a standstill and no lights burning, the hand should point at zero. If it does not, one of three conditions exists: Either the ammeter is out of calibration or there is a leakage of current in the wiring or the circuit breaker is not operating.

To determine if the ammeter is correct, disconnect one of the wires of the ammeter. If the indicating needle swings to zero, the trouble is leakage of current, which must be located immediately and corrected. If the ammeter hand does not point to zero with one of the wires disconnected, the instrument is out of calibration. This in no way affects the operation of the system, but, of course, it must be taken into consideration when reading the ammeter.

If the engine backfires when being shut down and makes one or more revolutions in the reverse direction, the ammeter needle may be found pointing to the extreme left side of the scale. This is caused by the circuit breaker points being held closed and means a short-circuit of the battery through the generator. This must be corrected immediately by disconnecting the generator or by separating the circuit breaker points or by cranking the engine.

If the wiring of the car is disconnected for any reason and on being connected again the ammeter shows a discharge with

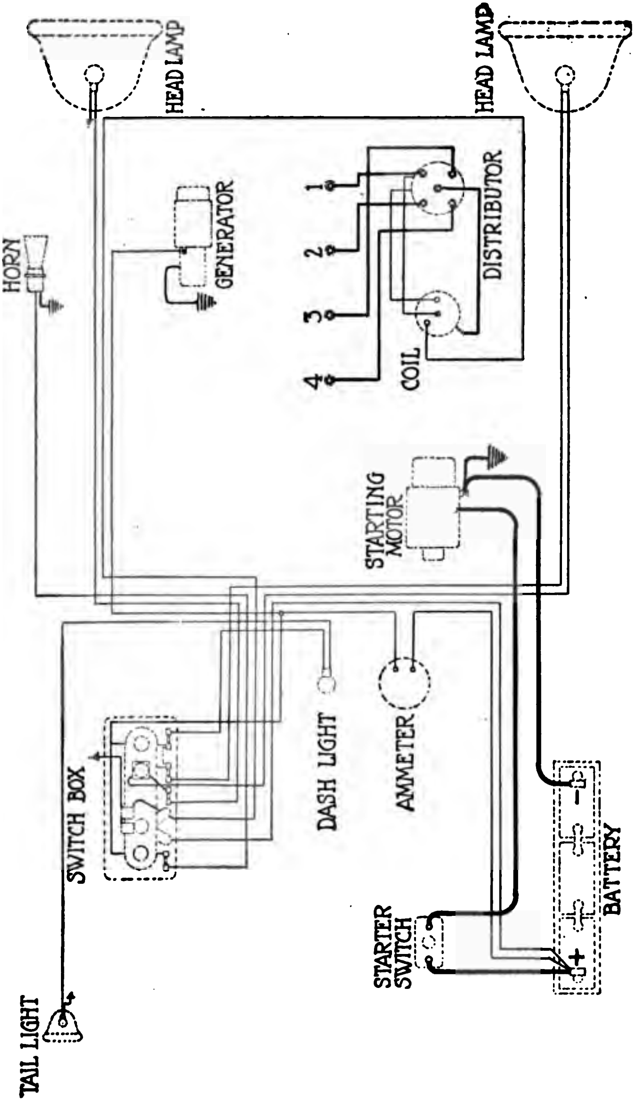


Fig. 169—Wiring diagram of Auto-Lite installation on Overland model 85B

no lights burning, the wiring should be inspected at once, for it is probable that some of the wires at the generator or circuit breaker have been connected wrong. If this is not corrected immediately the battery soon will be discharged.

The ammeter should be wired so as to read "charge" with the indicating needle pointing to the right, when the generator is charging the battery, and "discharge" with the needle pointing to the left, when the current from the battery is being used. If the indication is in the opposite direction it may be corrected simply by reversing the two wires connected to the terminals of the ammeter.

Ammeter Troubles and Causes

Ammeter burned out:

Excessive discharge due to short-circuit in ammeter to switch wire, wires from switch to lamp and horn or ammeter to circuit breaker wire. If discharge occurred with all switches "off," short is between ammeter and switch or ammeter and circuit breaker.

Ammeter shows discharge, no lights burning, motor stopped:

Circuit breaker points stuck or circuit breaker points set too close.

Ammeter shows charge with motor stopped, lights burning:

Circuit breaker point arm spring weak, partial short-circuit between ammeter and circuit breaker, or ammeter and switch box. Wire connections to the ammeter reversed.

Typical Wiring Diagrams

A diagrammatic wiring diagram of an Auto-Lite installation on a model 85B Overland car is shown in Fig. 169. A perspective view of the complete electrical installation on this particular car is shown in Fig. 170.

The starting-motor circuit may be traced readily by starting with the positive terminal of the battery, through the starting switch, thence to the starting motor through the motor and directly back to the negative terminal of the battery.

One terminal of the generator is grounded, which results in this terminal being connected to the negative terminal of the battery all the time, as the negative terminal of the battery is

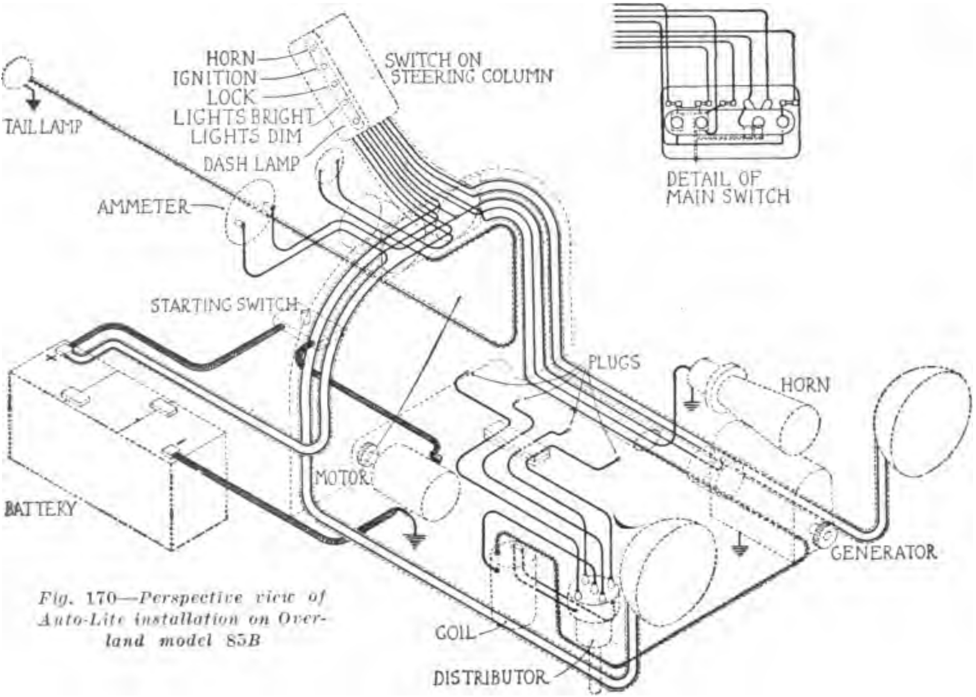


Fig. 170—Perspective view of Auto-Lite installation on Overland model 83B

grounded. The remaining, or positive, terminal of the generator is connected to the wire leading from the ammeter to the switch box when the contacts of the cutout, which is mounted at the generator, are closed. Any current being delivered by the generator in excess of that required to operate any lamps that are turned on and the ignition system will be delivered to the battery and the ammeter will indicate that the battery is being charged. If the generator current is not equal to that required by the lamps, etc., then the battery will be called upon to assist the generator and the ammeter will indicate that the battery is being discharged.

The dash and taillights are in series and controlled by a single switch.

The headlights are connected in parallel for full candlepower and in series when dimmed. A separate fuse is provided in each lamp circuit, and all the fuses are mounted on the switch block inside of the switch box on the steering column.

The ignition is independent of the generator, and the coil and distributor are mounted on the opposite side of the engine from the generator. The electrical connections are shown plainly in the diagrams.

A diagrammatic wiring diagram of an Auto-Lite installation on the Chevrolet is shown in Fig. 171, and a perspective view of the complete electrical layout is shown in Fig. 172. The starting-motor circuit is practically the same as the one shown in Figs. 169 and 170.

The generator circuit may be traced as follows: Starting with the ungrounded terminal of the generator you can trace along the conductor to the terminal A on the cutout, or circuit breaker, and if the contacts of the cutout are closed the circuit is completed to the terminal B on the ammeter, then through the ammeter to the terminal C on the starting motor switch, which is connected to the positive terminal of the battery by the heavy lead D. The negative terminal of the battery is grounded at the starting motor, and since the negative terminal of the generator is grounded the two negative terminals are connected permanently and the circuit connecting the generator and the battery is complete as long as the contacts of the cutout are closed.

The indication of the ammeter will depend upon the value and direction of the current through it, which in turn depends on the

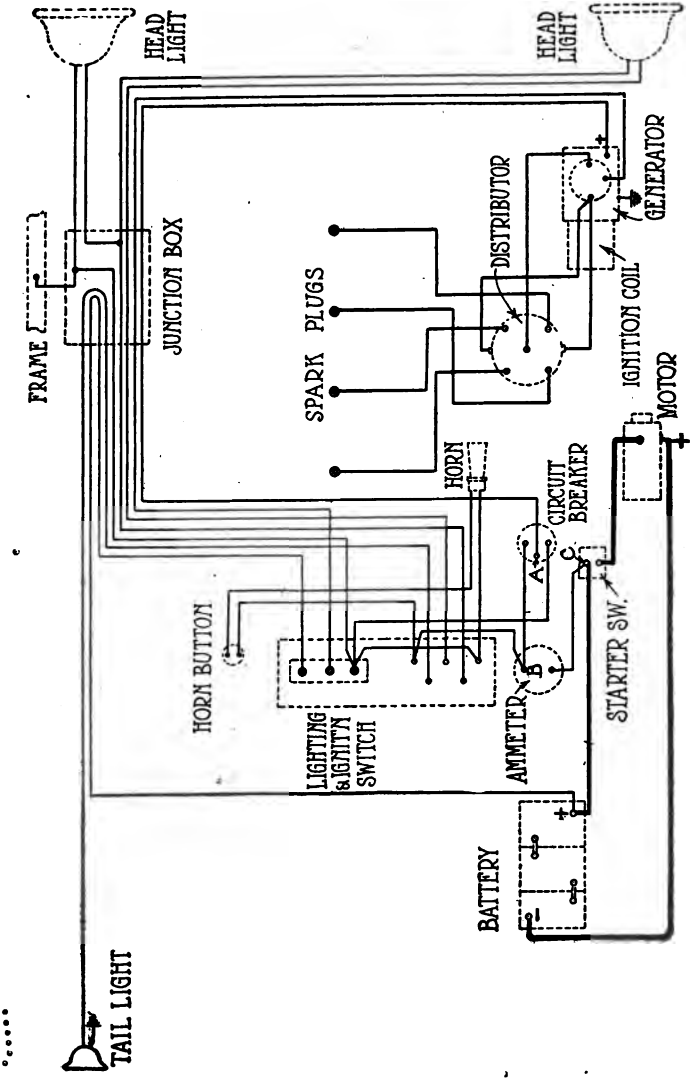


Fig. 171—*Wiring diagram of Auto-Lite installation on* 1917 *Chevrolet* value of the current, if any, supplied by the generator and the value of the current required to meet the demands of the lamps, etc. The current taken by the starting motor does not pass through the ammeter.

The wiring diagram of an Auto-Lite installation on the Detroiter car is shown in Fig. 173.

Instructions

The average motorist very seldom pays any attention to the workings of any part of his machine, and especially the electrical equipment, until it goes wrong, and then as a rule he is absolutely helpless. There is also another type of owner who spends quite a bit of time tinkering with his car and is often responsible for a great many of the cases of trouble that occur in connection with the operation of his car. Almost all manufacturers of electrical equipment supply the owner with all the necessary instructions for the care of the equipment on his car, and if these instructions are followed carefully little trouble will be experienced.

Care of the Generator

The silent chain drive of the Auto-Lite generator should be inspected occasionally and any undue amount of slack taken up by loosening the screw which holds the generator on its bracket and sliding the generator over by the adjusting screw. The chain should be so adjusted that there is no strain on the links when the engine is not running. After the adjustment is made the holding screws should be re-tightened.

The generator should be examined occasionally, and any carbon dust worn from the brushes should be blown from the case. The commutator should be kept bright and smooth. Loose segments in the commutator should be repaired at once, and the mica between the segments should be cut lower than the surface of the copper segments.

The brushes should seat perfectly and should be free in the holders. The spring tension should be sufficient to hold the brushes down but should not be excessive.

The cleaning of commutators and the fitting of brushes always should be done with fine sandpaper, never with emery paper or cloth. After smoothing a commutator, the particles of metal

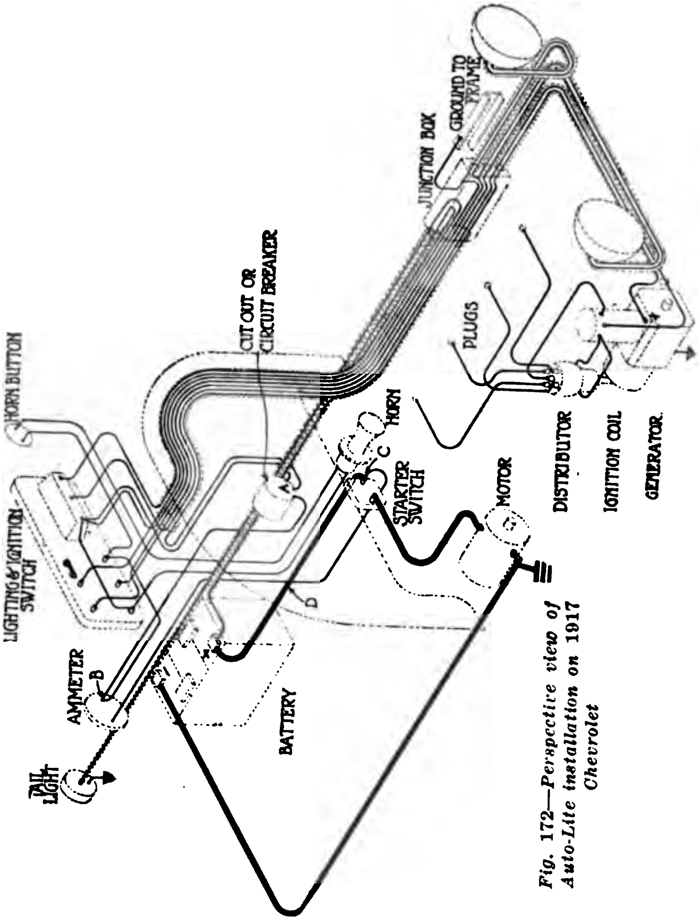


Fig. 172—Perspective view of Auto-Lite installation on 1917 Chevrolet

that bridge across the mica should be removed and the mica cut down. This must be done with the armature removed from the case. To start, use a three-cornered file, cutting a V notch in the mica. Follow this with a piece of hacksaw blade.

The brush holders must be insulated from the generator case perfectly. A test light readily will show if one is grounded.

If it is found that, due to excessive heat, the solder holding the armature leads to the commutator has been melted, a test for a ground should be made.

To determine if the field coils are grounded or short-circuited, insulate the brushes from the commutator or remove them, and close the circuit-breaker points with the fingers. If the ammeter shows more than 1½ amperes discharge, one or more of the field coils is short-circuited. They then should be tested singly with a test lamp.

Generator Troubles and Causes

Generator dead, as shown by the ammeter:
  Ammeter burned out or connection loose.
  Battery terminals loose, broken or corroded.
  Circuit-breaker points stuck and held open.
  Loose connection in circuit-breaker.
  Brush holders sticking or broken.
  Insulation burned or broken on armature.
  Field coils grounded or burned out.
Generator output low, as shown by the ammeter:
  Battery terminals loose or corroded.
  Circuit-breaker or ammeter wires loose.
  Brushes worn or broken.
  Brush holders sticking.
  Commutator dirty.
  Mica high between segments.
  Brushes grounded by carbon dust.
  Segments worn or cut.
  Field coils loose or broken.
  Battery plates sulphated.
Generator brushes noisy or sparking:
  Brushes worn or broken.
  Brush holders sticking.
  Commutator dirty or rough.

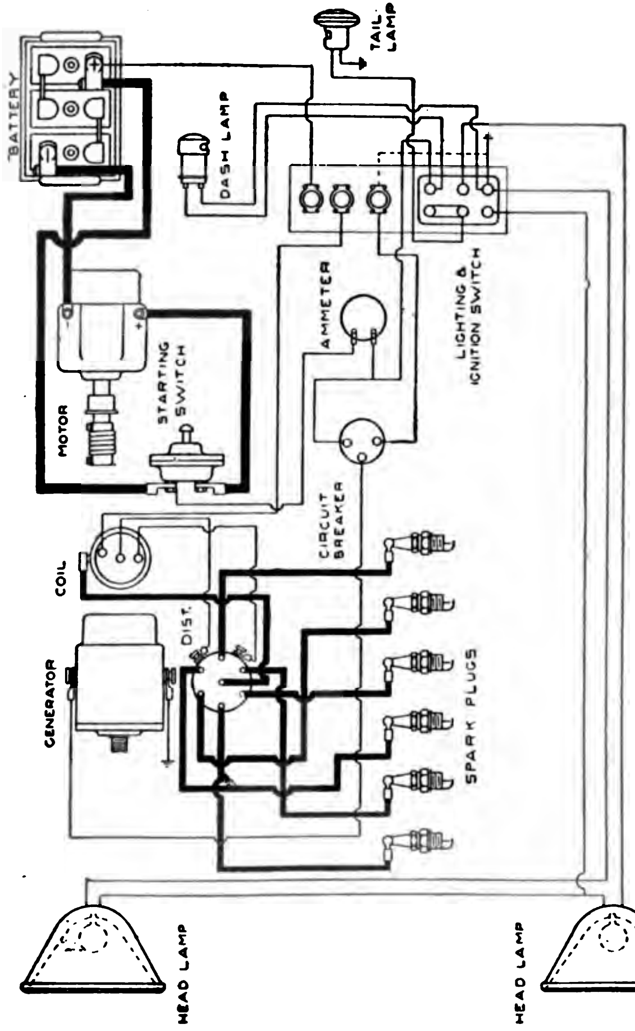


Fig. 173—Auto-Lite installation on the 1917 Detrotter

Mica between segments too high.
Brush not fitting the commutator.
Brush spring broken.
Brush setting wrong.
Loose segment in commutator.

Commutator cut:
Brushes worn or broken.
Brush spring tension too tight.
Brushes too hard.

Armature binding cord-cut:
Field coils loose.
Brush holder broken.

Field coils grounded:
Insulation worn or broken.

Field coils burned out:
Loose connection at generator.
Circuit breaker, ammeter, battery or starting motor ground.

Care of Starting Motors

The starting motor cranks the engine mechanically, power being applied to the flywheel through the medium of the Bendix drive, as shown in Fig. 174. The jar or shock of setting the flywheel in motion is absorbed by the coil spring on the starting-motor shaft. When the electric circuit is closed by pressing the starting switch button the armature of the starting motor starts to rotate. The Bendix drive pinion, which is carried on a threaded sleeve on the starting-motor shaft, is prevented from turning by an eccentric weight.

The threads lead the pinion along this sleeve until it fully engages with the teeth of the fly wheel. Farther lateral travel is prevented by a stop on the sleeve, and the pinion starts rotating with the starting motor and so transmits turning movement to the flywheel.

No oil or grease should be placed on the threaded sleeve on which the drive pinion is mounted as this is liable to gum and cause trouble. It is better to wash off any accumulation of dirt or dust occasionally with kerosene and allow the pinion to remain dry.

Starting Motor Troubles

Sparking and burning when switch is depressed:
- Switch to motor wire insulation broken.

Starting motor noisy:
- Bendix drive gears improperly meshed.
- Brushes noisy.
- Bearings seized to shaft.
- Bearings broken.

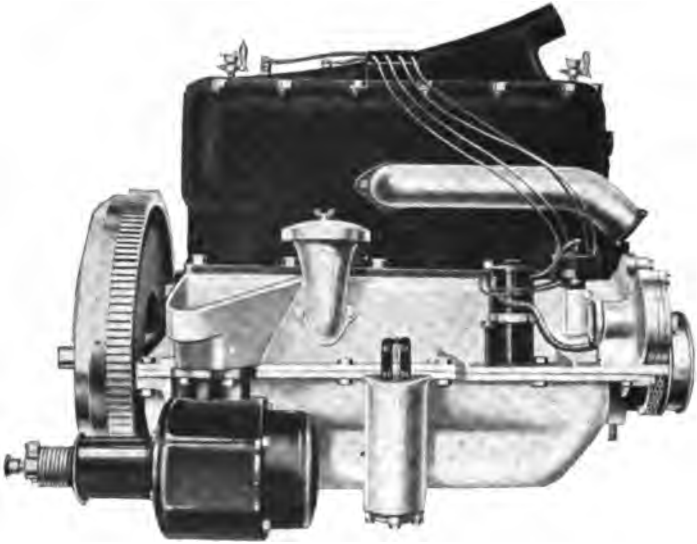


Fig. 174—*Auto-Lite starting motor and ignition system installed on* 1917 *Overland engine*

Starting switch sticks:
- Spring broken.
- Button stuck in switch body.
- Contact points burned.

Starting motor does not turn:
- Battery low or discharged.
- Battery terminals loose, broken or corroded.
- Battery frozen.

- Switch to starting motor wire insulation broken.
- Loose connection at switch or motor.
- Switch contacts burned.
- Brushes worn or broken.
- Commutator dirty.
- Brush lead broken.
- Brushes sticking in holders.

Starting motor turns slowly:
- See "Starting Motor Does Not Turn."
- Brush springs weak.
- Bearings broken.
- Polarity of one or two cells reversed.
- Field or armature winding burned out or grounded.

Starting motor turns but the engine does not turn:
- Bendix drive pinion sticking on sleeve.
- Bendix drive spring broken.
- Flywheel teeth broken.

Starting motor does not release but turns with the engine:
- Switch sticks.
- Bendix pinion sticking on the sleeve.

The starting motor should be given the same general care as the generator, as regards brushes, commutator, brush holders, etc.

If the starting motor does not operate, due to a grounded wire, inoperative switch or some similar cause, the wire from the battery to the starting switch should be disconnected at the battery and the engine cranked by hand.

Lights

The lighting system of the Auto-Lite installations is a 6-volt system securing its current from the storage battery and generator. The dashlamp and taillamp are connected in series, so if the taillamp fails the dashlamp will go out also and serve as a warning. Single-contact bulbs are used in these two lights.

The headlights use double-contact bulbs and are connected in series when dimmed.

A separate fuse is provided in each lamp circuit, and all fuses are mounted on the switch block within the steering column control box. One spare fuse is provided also.

The headlights are focused by a screw at the back of the lamp, either in the center or just above the center of the lamp body.

Turning this screw to the right or left moves the lamp bulb in or out as the case may be. Adjust the bulb so that when the light is turned on a vertical surface 10 feet away, the light shows clear and even, without any rings.

To clean the lamp reflectors use a small piece of cotton dipped in alcohol and wipe from the bulb out to the edge. Never use any polish or grit on a reflector and never wipe or rub with a circular motion.

Lighting Troubles and Causes

No lamps light:
- Fuses burned out.
- Battery discharged.
- Battery terminals loose, corroded or broken.
- Battery ground wire broken or loose at starting motor.

Broken or loose connection between battery and ammeter or between ammeter and switch:
- Ammeter burned out.
- Lights burned out.
- Battery frozen.

One or both headlamps do not light with the switch in "bright" position, or dash and taillamps do not light:
- Lamps burned out.
- Poor contact between lamps and sockets.
- Broken wire or loose connection between switch box and lamps.

Lamps burned out:
- Battery terminals corroded.
- Loose connection at the battery or the ammeter.
- Battery ground loose at the starting motor.

Dashlamp burned out:
- Wire from dashlamp to taillamp grounded.

Lights flicker or fluctuate:
- Broken or loose connection in switch box.
- Poor lamp grounds.
- Battery terminals loose or corroded.
- Poor connection at battery ammeter or starting motor.
- Battery electrolyte low.

Lights dim at all times:
- Bulbs improperly focused.
- Battery discharged.

Battery frozen.
Short-circuit in battery.
Polarity of one or two cells reversed.

Auto-Lite Ignition Systems

The breaker and distributor points should be kept clean and free from oil. In the event that the contact points become so worn that their adjustment is impaired, it will be necessary to renew the entire breaker bar element. This should not occur, however, within 25,000 to 35,000 miles of ordinary running. When this is necessary remove the cover from the coil and disconnect the wire that runs direct to the breaker plate.

Remove the distributor cover with wires attached and take out the distributor arm.

Unscrew the two round-headed screws which hold the retaining ring and breaker plate in the case.

Lift the breaker plate from the housing and the retaining ring and screws will come with it, also the wire which connected it to the coil. This wire should be replaced in the new breaker arm, which should be installed as received from your dealer.

Never attempt to readjust the points on a new breaker plate. The only lubrication necessary is the use of vaseline in the grease cup on the timer shaft just below the timer body.

An ignition coil is provided to transform the low-tension battery current into a secondary high-tension current with sufficient pressure to force the current across the spark plug gap when under compression.

Should any internal trouble occur the repairs should be made by the manufacturer. An internal short-circuit in the coil will evidence itself in misfiring which cannot be traced to any one cylinder.

An automatic cutout is placed in the ignition switch which will open the ignition circuit if the button is inadvertently left in the ''on'' position while the motor is stopped. This switch is controlled thermostatically, depending for its operation on the heating of a thermostatic metal spring by a coil of resistance ribbon through which all current supplied to the ignition is conducted. Since the current supplied while the engine is running is intermittent, it does not heat this thermostatic spring to a temperature which will cause it to deflect and make the necessary contact with the tripping mechanism to operate the cutout.

Should the switch be left "on" the flow of current is continuous and the thermostatic spring is heated and deflected so that it makes a contact permitting the current to flow through a vibrator coil which operates the tripping mechanism and allows the switch button to be thrown out.

Ignition Troubles and Causes

Motor will not start, ignition dead:

- Battery discharged.
- Battery connections loose.
- Distributor points dirty.
- Coil burned out.
- Primary wire disconnected or broken.
- Secondary wire grounded.
- Breaker arm stuck.
- Distributor arm spring broken.
- Breaker points set too wide.
- Timer drive gears inoperative.

Motor starts hard:

- Battery discharged.
- Spark plug points dirty or too far apart.
- Distributor points dirty.
- Breaker points sticking.

Motor misses at all speeds:

- Spark plugs dirty, broken or improperly set.
- Spark plug wire shorted.
- Battery weak.
- Battery connections loose or corroded.
- Connections at switch, coil, breaker or distributor loose or corroded.
- Breaker points worn, burned or improperly adjusted.
- Breaker arm sticking.
- Condenser broken down.

Motor misses at high speed only:

- Spark plug gap too wide.
- Breaker or distributor points dirty.
- Breaker arm sticking.

Motor misses at low speed, idling:
 Spark plug points too close.
 Battery weak.

Motor misses at low speed, on pull:
 Spark plug gap too wide.
 Battery weak.

Spark knock:
 Ignition set early.

Spark plugs failed:
 Cylinders carbonized.
 Misfiring in cylinder at fault.

Popping in muffler:
 Spark set late.

Ignition switch does not throw out when car stops:
 Points set too far apart.

Ignition switch throws out while running:
 Points set too close.

Distributor points burned:
 Condenser open.

Automatic ignition switch coils burned:
 Automatic trip stuck.

The symptoms and causes given cover only ignition. If the engine will not start or starts hard, determine first if a spark is being delivered at the spark plugs. A check of the causes given for these symptoms will show the trouble. If a good spark is being delivered in each cylinder, look elsewhere for the trouble. Should the battery be discharged, the only means of operating the car until the storage battery is recharged is to install a battery of four or five dry cells, in series, disconnecting the ignition wire from the storage battery and connecting it to the carbon post of the first dry cell. The other connection from the dry cells should be grounded to the frame. If no dry cells are available, ignition current can be secured from the generator, in an emergency, by having the car towed at a speed of 10 or 15 m.p.h., with the transmission in high gear until the engine starts. This will turn the generator fast enough to close the circuit breaker and force current through the dead battery. The same result can be had by coasting down a hill if convenient.

If the battery is charged and no spark can be secured, examine connections, plugs, breaker points and such possible causes before ever changing any adjustments.

If an apparent cause for trouble is found, always try to determine if that is the basic trouble. For instance, if a cylinder is misfiring the spark plugs probably will be dirty, but this need not be the cause, for the plugs get oily and dirty because the engine misfires for some other cause. Again, there may be some more serious cause for the spark plug being dirty, such as excessive lubrication or oil leaking past the piston due to broken or worn rings, scored piston or cylinder, bent connecting rod, etc.

If misfiring is confined to one cylinder, locate that cylinder. That is done easily by short-circuiting the spark plug, holding a screwdriver with an insulated handle between the engine block and the spark plug wire terminal. If in testing the various spark plugs in turn, one is found which, when short-circuited, does not cause further misfiring, it is in all probability the one at fault.

Spark Plugs

The most common fault found in the spark plugs is carbonizing or sooting, which results in short-circuiting the high-tension current so that instead of jumping between the spark plug points or electrodes in the cylinder combustion chamber, it passes through the carbon accumulation directly to the grounded metallic shell. The plug should be removed, and if there is evidence that it is short-circuited the carbon accumulation should be removed by scraping off the carbon and then washing the plug with gasoline and a stiff brush. Carefully inspect the plug to determine whether the porcelain has become cracked or damaged in any way.

The porcelain may be cracked in such a manner that it will not show upon casual inspection, but it may be detected as follows: If the plug is screwed into the cylinder and pressure is brought to bear against the upper part of the plug with the finger, a grating or grinding noise sometimes will be heard and only a very little motion can be felt.

In case of a broken porcelain the high-tension current will bridge the gap between the center electrode and the plug shell through the crack in the porcelain rather than jumping the space between the spark plug points when under compression. Before installing a plug see that points are properly set at $\frac{1}{32}$ inch, or about the thickness of a smooth dime. An infallible test for the plug is to replace it with one that is known to be perfect. If the condition of operation is not changed, examine spark plug wire.

If the insulation, or rubber covering, on the spark plug wire is broken or worn through and this point should come close to any metal part of the car the high-tension current will short at this point and will not pass through the plugs. It is not necessary that the insulation be worn down to the metal of the wire. If a sharp snapping is heard when the engine is under a heavy pull, it is evidence of short-circuit of the high-tension wiring and the fault usually will be found with imperfect insulation of the spark plug wires. Should the plug and plug wire show no evidence of fault, examine the distributor arm in the distributor for poor contact.

Ignition Timing on Overland

Ignition timing should be adjusted only by an experienced repair man. When properly set with a fully retarded spark lever the dead center mark on the flywheel should be past the check mark on the crankcase, as follows:

Overland model 85-4	$1\frac{5}{32}$ to $1\frac{7}{16}$ inches
Overland model 85-6	¾ to 1¼ inches
Willys-Knight model 88-4	2¼ to inches
Willys six model 88-6	¾ to 1¼ inches
Willys-Knight model 88-8	1½ to inches
Willys six model 89-	¾ to 1¼ inches
Overland model 90-	$\frac{63}{64}$ to 1¼ inches

Locating Short-Circuits

A short-circuit may occur at any point in the electrical system but usually is found in the connector or switch terminals and usually is caused by frayed ends of wires bridging across the terminals. A short-circuit may be caused by a double ground, that is, wires of opposite polarity may be in metallic contact with the frame of the machine. The ammeter always will show whether or not a short-circuit exists in any part of the wiring, except from the battery to the switch bus bar and in the starting motor and ignition circuits. To make a complete test for short-circuits proceed as follows:

Examine carefully every inch of the conductor wires connected at one end of the battery terminals and at the other end to the bus bar of the lighting switch. Make certain that the insulation is perfect and that no metal corners or edges cut through, also that no wire ends or strands touch another connector. In the same manner examine carefully the wiring from the battery to the starting motor and starting switch. Give particular attention to the ends of the armored wire to make sure that the armor has not cut the insulation. If the battery has been discharged, have it fully charged. Tag or mark the wires and battery leads or binding posts before removing the battery for charging, so that the wires can be connected again exactly as they were.

When replacing the battery connect the ground wire that runs to the starting motor, to the negative terminal of the battery. The other wires, of which there will be three or four, should be connected to the positive terminal. Before connecting these wires to the positive terminal touch each one to the terminal quickly, and watch for the smallest spark. If there is any spark whatever it indicates a short-circuit or ground in that circuit. Trace the wire carefully until the trouble is found. With all switches ''off,'' grounds or shorts will be found as follows: In the starting-motor circuit, between the battery and the starting switch; in the ignition circuit, between the battery and the steering column switch box; in the lighting circuit, between the battery and the ammeter or between the ammeter and the switch box or between the ammeter and the generator; and in closed cars only, between the battery and the switches for the dome or wall lights.

If the short is in the generator circuit, disconnect at the cutout or circuit breaker the wire leading to the ammeter. If the short still shows with this wire disconnected, the trouble is in the wiring. If not, the trouble may be in the circuit breaker itself.

If no sparking occurs, make a second connection to the battery. Then with the engine at a standstill, close the several switches to the lighting circuit, one at a time, and watch the ammeter needle perform as each switch is closed. If the needle springs to the extreme left side of the instrument and holds there, a short-circuit exists somewhere in the circuit whose switch is closed, between a switch and that light or horn. Try all circuits in this manner, one at a time. If the ammeter indicates only the proper amount of current consumption of the several lighting circuits, as they are switched on, no further search for short-circuits is necessary. However, if the ammeter needle springs against the side of the case, while on one or more circuits, proceed as follows:

Trace out the circuits, watching carefully for grounds and short-circuits. If no trouble is found in the wiring, it will be located in the lamp sockets, the connector or the bulb itself. The trouble must be corrected and repairs made very carefully to prevent a possibility of a recurrence. In case one or more bulbs fail to burn, the trouble may be due to burned-out bulbs or defective connection at the switch box connectors or lamp sockets. Trace out the defective circuit carefully until the trouble is located.

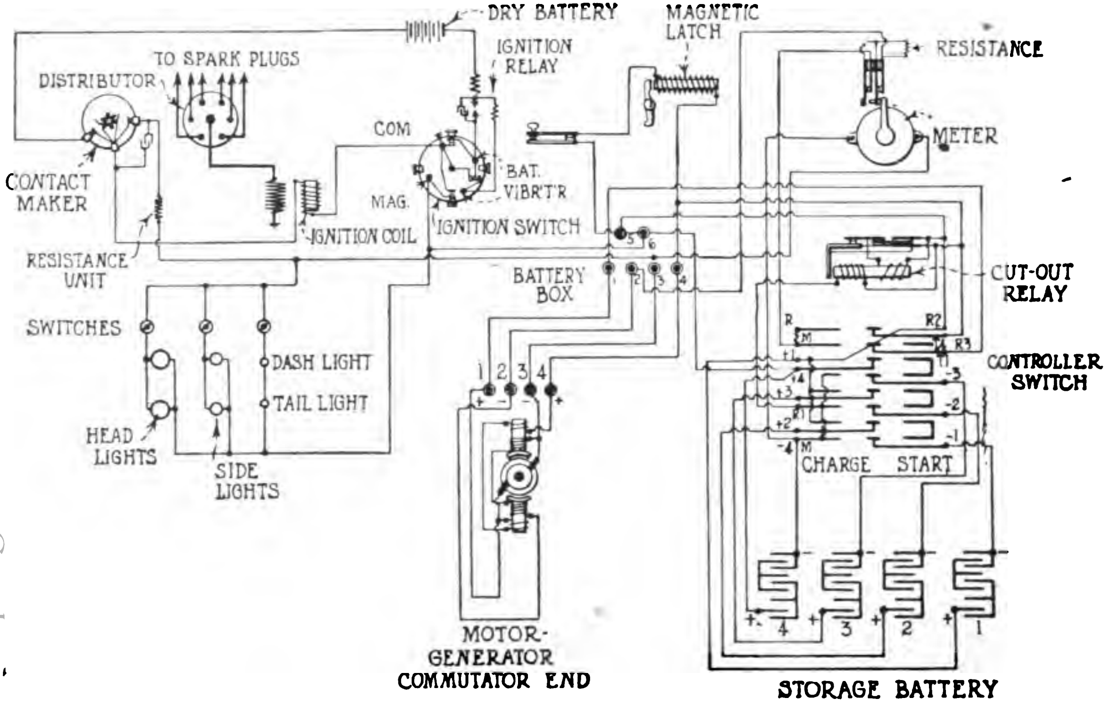


Fig. 175—*Delco 6-24-volt system used on* 1913 *Cole models,* 4-40, 4-50 *and* 6-60

CHAPTER XX

Delco Electrical Systems for the Motor Car

SEVERAL different types of starting, lighting and ignition systems have been built by the Dayton Engineering Laboratories Co., Dayton, Ohio, and a brief description of a typical example of each of these systems will be given in the following paragraphs.

6-24-Volt, Single-Unit, Two-Wire

This type of electrical equipment was used on the 1912 Cadillac and on the Cole, Hudson, Oakland and Oldsmobile cars during 1913.

The principal units are a two-pole combination motor and generator with a single armature winding which generates at 6 volts and operates as a motor on 24 volts; a storage battery of four groups of three cells each, connected to a special controller in such a way as to permit of series or parallel grouping; a dual ignition system using current from the generator and also providing for ignition from five dry cells. The special controller is mounted in the battery box. The system is free from grounds. Six-volt lamps are used. The circuit between the generator and the battery is opened and closed by an electromagnetic cutout. This cutout is mounted above the special controller, and in addition a special ampere-hour meter is mounted in the battery box and serves to regulate the output of the generator. The two-wire system is used throughout. No fuses or circuit breakers are used. A wiring diagram of a system of this kind is shown in Fig. 175.

Starting Operation

When the starting switch is depressed it closes the circuit at its two contact points, and the following results are accomplished. The circuit is completed from the 6-volt battery through the winding of the magnetic latch and the series field and the armature windings of the electrical unit, which causes the armature to revolve, and the machine acts as a series motor. No power is transmitted to the engine crankshaft, as the shaft of the electrical unit and the crankshaft are connected by an over-running clutch which is capable of transmitting power only from the engine to the electrical unit. If the clutch pedal is pressed down now, the gears connecting the electrical unit and engine crankshaft are meshed and the controller thrown over to the 24-volt position, and the series winding of the electrical unit and its armature are connected directly in series with the 24-volt battery. If the ignition button has been depressed the engine should now start to operate under its own power. When the engine picks up and runs faster than the electrical unit tends to operate it the starting clutch will slip and the driving clutch on the opposite end of the shaft will take hold and drive the electrical unit. The clutch pedal should be released as soon as the motor fires. When this pedal is released the special controller switch is changed from a 24-volt battery connection to a 6-volt connection, and the starting gears are disengaged.

A simplified diagram of the electrical circuit for operating the starting motor is shown in Fig. 176. This diagram is applicable to all 6-24-volt systems and it shows the manner in which 6 volts is maintained at the lights while 24 volts is applied to the starting motor.

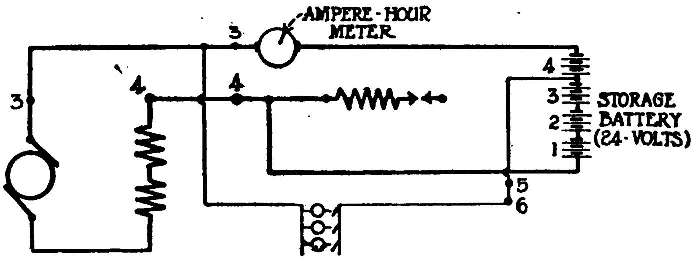


Fig. 176—*Wiring diagram of the starting-motor circuit for all 6-24-volt Delco systems*

Regulation of Generator Output

As soon as the engine exceeds a certain speed the generator produces enough electrical pressure to close the cutout relay, which connects the generator terminals to the storage battery through the ampere-hour meter. While the battery is charging the large hand on the ampere-hour meter revolves slowly in a counter-clockwise direction. The small hand on the meter merely serves as a means of determining at a glance if the battery is charging or discharging.

The shunt-field current of the electrical unit can be traced as follows: Starting with the terminal on the electrical unit marked 1 in Fig. 175, then to the terminal marked 1 on the battery box, then to the second terminal from the top on the side of the knife switch toward the battery, through the contact of the knife switch when it is closed, thence to one of the contacts directly above the ampere-hour meter. Terminal 2 on the electrical unit also is connected to one of the contacts directly above the ampere-hour meter, as shown in the diagram. An inspection of the diagram will disclose the faet that the electrical circuit is completed through the two sets of contacts at the ampere-hour meter and will remain so until the large hand moves back to zero, when it will cause the right set of contacts to open and thus introduce the resistance in series with the shunt field. A further movement of the large pointer will cause the left set of contacts to

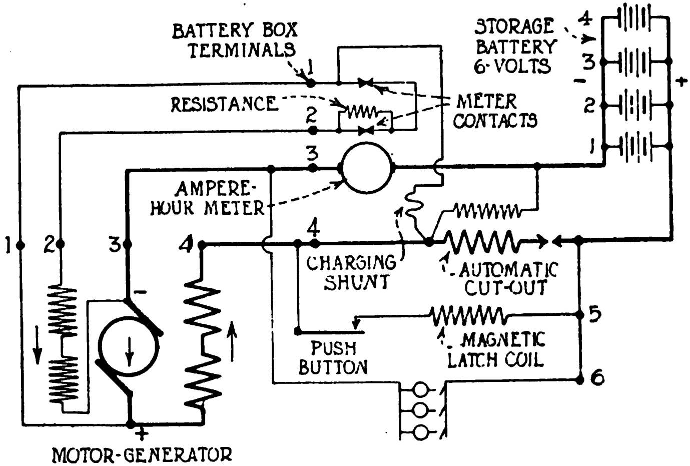


Fig. 177—Wiring diagram for all 6-24-volt Delco systems when the machine is operating as a generator

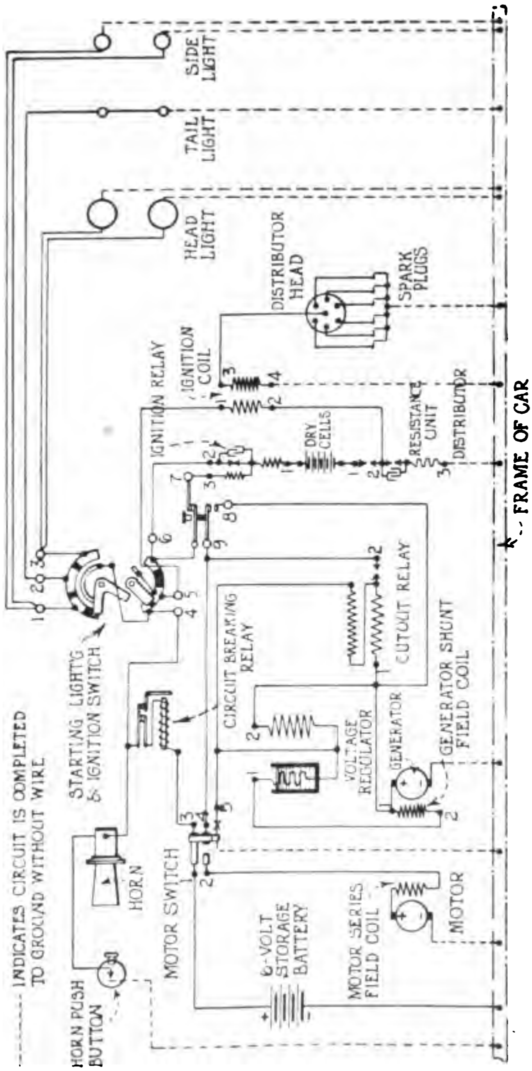


Fig. 178—*Wiring diagram of Delco installation on 1914 Moon model 6-50*

open and thus opens the field circuit. The introduction of the resistance in the field circuit of the electrical unit reduces the voltage generated in the armature and hence the current it delivers to the battery. When the condition of charge has reached a certain point the voltage of the electrical unit is reduced to practically zero value by opening the field circuit and the cutout immediately disconnects the battery. As the battery becomes discharged the large hand on the ampere-hour meter will turn in a clockwise direction and the contacts will be restored to a closed position.

A diagram of the charging circuit for all Delco 6-24-volt systems is shown in Fig. 177. This shows all connections as they exist when the machine is operating as a generator. The heavy lines indicate the path of the main charging current.

Systems With Mercury Well Regulator

The systems using the mercury well voltage regulation conveniently may be classified as follows:

Two-terminal electrical unit.
Four-terminal electrical unit.
Electrical unit equipped with motor brush switch.
Two-terminal electrical unit with mercury well regulator.

Two-Terminal Electrical Unit

The two-terminal electrical unit has a single armature but the armature is equipped with two commutators. The larger of the two commutators, which is toward the front of the car, is used for the generator operation, while the smaller one, which is toward the rear of the car, is used for the starting motor operation. The electrical unit is provided with two field windings, a shunt and a series. The shunt-field winding is connected between the two terminals on top of the electrical unit. The series-field winding, which is used for the starting motor operation, is connected between the positive starting motor brush and the conductor leading to the starting motor switch.

The shaft of the electrical unit, when it is operating as a generator, is driven by an over-running clutch carried inside the housing of the machine. When the unit is acting as a starting motor the drive is to the flywheel through a pair of sliding gears. The larger one of the gears has an over-running clutch mounted in it.

The system is of the 6-volt, single-wire type with the negative

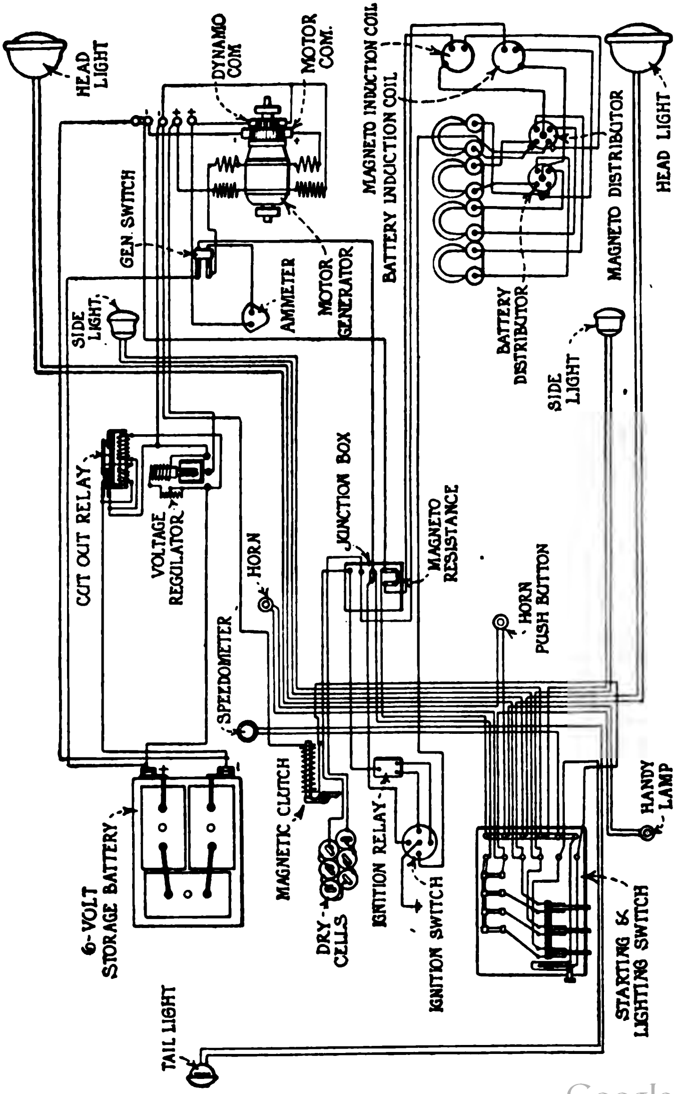


Fig. 179—*Wiring diagram of Delco installation on 1913 Cadillac* terminal grounded. The voltage of the generator is controlled by a mercury well regulator. A complete description of this type of regulator will be found in one of the chapters of Vol I. An electromagnetic cutout of the usual Delco type provides a means of automatically connecting and disconnecting the generator and storage battery. The wiring diagram of a system of this kind as used on the 1914 Moon car model 6-50 is shown in Fig. 178.

The starting operation is, briefly, as follows: When the starting button on the combination switch is depressed, a circuit is completed from the storage battery through the generator armature and back to the battery, which causes the armature to rotate slowly and thus allow the train of gears connecting the pinion on the shaft of the electrical unit and the gear on the flywheel to mesh easily. When the starting pedal is thrown forward it puts the gears into mesh and operates the starting motor switch. The starting switch does not move into its closed-circuit position immediately upon pressing the starting pedal, but a coil spring is compressed and when the starting pedal has about reached the extreme end of its travel a latch is tripped and the starting switch quickly is closed.

Four-Terminal Electrical Unit

The four-terminal electrical unit with mercury well regulator is a two-pole machine with its poles on a vertical axis and each pole provided with a shunt and series winding. Four small terminals and one large terminal are provided on the front end of the electrical unit, or the end toward the front of the car. The electrical unit is provided with an armature but this armature has two windings and two commutators. The larger of the two commutators, which is toward the front of the car, is used in the cranking operations, while the smaller of the two commutators, toward the rear of the car, is used when the electrical unit is operating as a generator. The driving connections between the armature of the electrical unit are practically the same as those used for the two-terminal electrical unit.

The equipment used in the cranking operation is a combination of that used in the 6-24-volt system and that used with the two-terminal electrical unit system. The first operation, of course, in cranking is to close the starting button on the combination

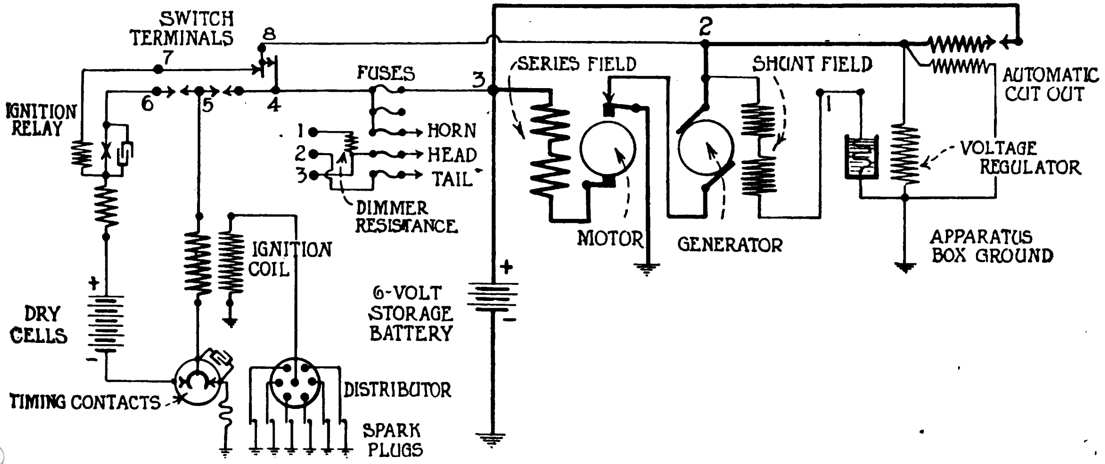


Fig. 180—*Wiring diagram of Delco installation on* 1914 *Hudson model* 6-54 switch. When this switch is closed the magnetic latch coil is energized and a circuit is completed through the generator armature, causing the armature of the electrical unit to revolve slowly, which greatly assists in the meshing of the starting gears. The wiring diagram of a good example of a system of this kind is shown in Fig. 179. The energizing of the magnetic latch coil links the mechanism which operates the gears and starting switch to the clutch pedal shaft. Depressing the clutch pedal then puts the gears into mesh and closes the starting motor switch.

The system is of the two-wire ungrounded type and for this reason four terminals are required on the electrical unit. The terminals on the electrical unit, as you face the terminal end, are connected as follows: The left terminal is connected to the positive brush of the generator, the next terminal is connected to the end of the upper shunt field coil, the third terminal is connected to the negative generator brush and also the terminal of the lower shunt field coil, and terminal No. 4 leads to the negative motor brush.

In this system no circuit breaker is employed to protect the battery against overload on the lighting circuits, but a protection is provided in these circuits by introducing suitable fuses.

Regulation of Four-Terminal Unit

The regulation of this electrical unit while it is operating as a generator is the same as in the case of the two-terminal type of electrical unit, which has already been described, with the following addition. An adjustable resistance is connected in series with the winding of the mercury well regulator by which the charging rate of the generator can be changed. It is advisable to increase the charging rate in cold weather and reduce it in warm weather. The adjustment in the resistance is brought about by moving a small lever which has one of its ends extending through a slot in the cover of the regulator. When this lever is at the left end of the slot the charging rate is reduced to its lowest value, and when it is at the right end of the slot the charging rate is at its maximum value.

The lighting and ignition switches are carried on the dash. The lighting switch is provided with three push buttons which control the various lighting circuits and, in addition, a fourth button which is called the starting button. The ignition switch serves to make the necessary connections for the ignition circuits. There are four plungers on the switch. The lower plunger is marked "start." When it is depressed a shower of sparks is produced across the spark plug points. This switch should be used only in starting the engine. The button at the left is marked "B." It puts the dry battery ignition system into operation when it is depressed. The button at the right is marked "M." It puts the generator ignition system into operation when it is depressed and at the same time causes the button B to be released thus killing the dry battery ignition. The button at the top is marked "Lock" and "Open," and when it is pushed in it releases any of the other buttons that may be depressed and thus cuts off the ignition from either source. This top button is provided with a locking device which is made operative by turning the button so the word "Lock" is at the top. The button must be turned so the word "Open" is at the top in order that any of the other buttons may be depressed.

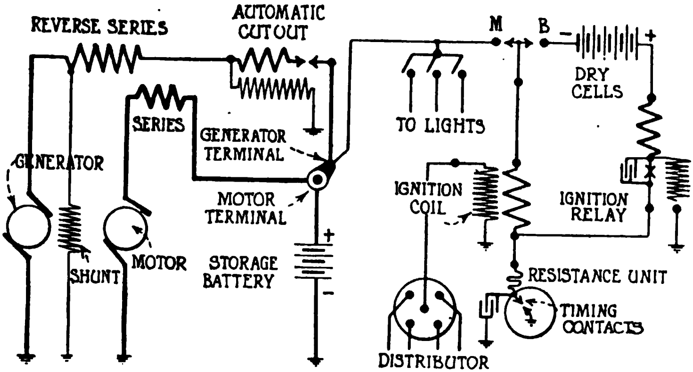


Fig. 181—*Wiring diagram of Delco installation on* 1914 *Buick model B*-24-25

Unit With Motor Brush Switch

A good example of a Delco electrical unit equipped with a motor brush switch and mercury well regulation is shown in the wiring diagram in Fig. 180. The system is of the single-wire type, and the negative terminal is grounded as shown diagrammatically in the figure. When the starting button, shown at 8 in the wiring diagram, is depressed current is sent through the armature of the generator and shunt-field winding, which causes it to rotate slowly. Pressing down on the starting pedal opens the generator circuit at the negative brush of the starting motor, throws the starting motor gears into mesh and closes the circuit through the armature and field winding of the starting motor. As soon as the starting pedal is released and the speed of the generator reaches a sufficient value so that the current produced in the winding of the cutout pulls its contacts together, the generator will start to charge the battery and will continue to do so unless its voltage drops below that of the storage battery.

Delco Junior System 1914

The electrical unit used in connection with this system is a combined motor and generator with a single armature equipped with two commutators, both being at the end of the armature toward the front of the car. The larger commutator is nearer the armature winding and is for the starting motor operation while the smaller commutator is for the generator action. The system is of the single-wire, 6-volt type with the negative side grounded to the frame of the car. A wiring diagram of a system of this kind is shown in Fig. 181.

An electromagnetic cutout is located inside the upper part of the housing of the electrical unit which performs a double function. When the starting pedal is depressed the cutout contacts are closed by one arm of a bell crank which has its remaining arm connected to the rod that operates the sliding gears. As soon as the cutout contacts are closed a current will be produced in the shunt-field winding and the generator armature winding of the electrical unit, which will cause the armature of the electrical unit to rotate and thus assist in meshing the driving gears. Attached to the rod which moves the gears into mesh with each other is a rod which extends through the housing of the electrical unit. When the starting pedal is depressed this long rod is drawn toward the rear of the housing and causes the starting motor brush, which normally is raised from the commutator, to make contact with the commutator and one of the generator brushes is raised, which opens the generator charging circuit. When the starting pedal is released the motor brush is raised, the generator

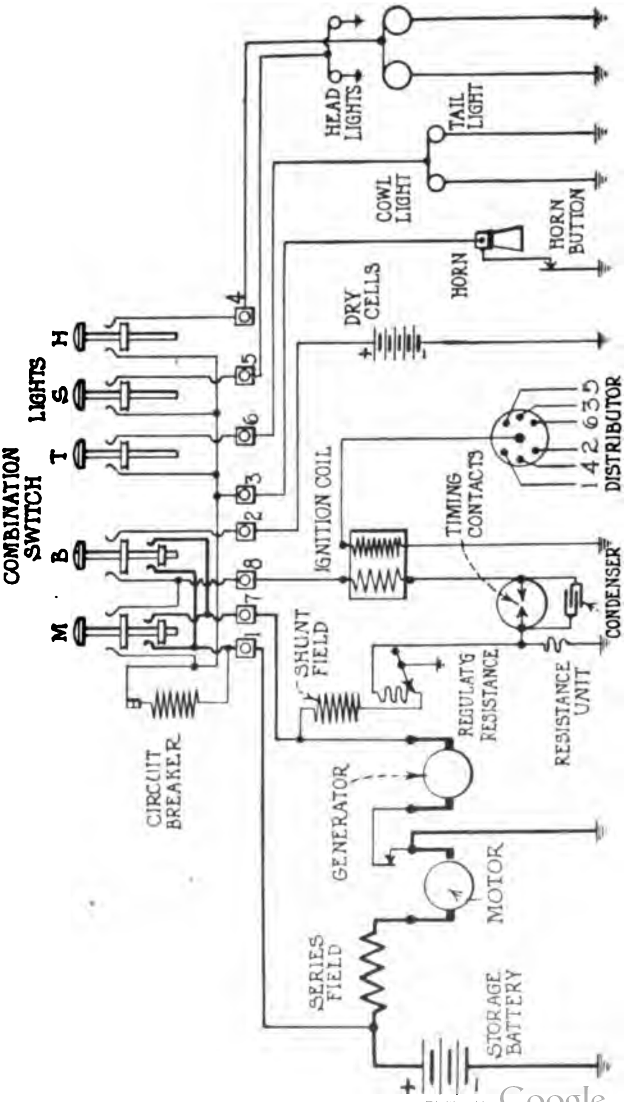


Fig. 182—Wiring diagram of Delco installation on 1915 Auburn model 6-40

brush is restored to its normal position on the commutator and the cutout contacts are allowed to open unless the current in the winding of the cutout is ample to keep the contacts closed.

The electrical unit is provided with three field windings as shown diagrammatically in the figure. The series field winding is in service only when the electrical unit is being used as a motor. The shunt-field winding is connected directly across the terminals of the generator armature. The reverse series-field winding is in series with the line from the generator to the cutout and carries all the current being delivered by the generator. The magnetizing action of this reversed series-field winding is opposite to that produced by the shunt-field and as the current delivered by the generator increases an increased demagnetizing action is produced, which tends to prevent an increase in the current delivered, as the voltage generated in the armature winding will not be as high as it would be if the magnetic field were not acted upon by the reversed series-field winding.

Five-Button Dash Switch Systems 1915

The Delco electrical systems for 1915 are equipped with the dash type of switch, which has three lighting buttons and two ignition buttons. Three different types of equipment will be considered. The main difference in these systems is in the method employed in regulating the output of the generator.

Regulation by Centrifugal Governor

The type used more than any other is one in which the current output of the generator is regulated by a centrifugally-operated governor and field resistance. This type is used on the Auburn, Buick models 38 and 54, Cole 6-50, Hudson 6-40, Jackson, Moon, Oakland, Oldsmobile, Paterson and Westcott.

A wiring diagram of an installation of this kind on the 1915 Auburn 6-40 is shown in Fig. 182. The amount of the regulating resistance in series with the shunt field of the generator is determined by the speed of the shaft of the electrical unit, which causes the contact arm to move up and down on the regulating resistance by the action of the centrifugally-operated governor.

The starting operation is performed as follows: Button M on the combination dash switch is pulled out, and this closes two circuits. One may be traced from the positive side of the battery

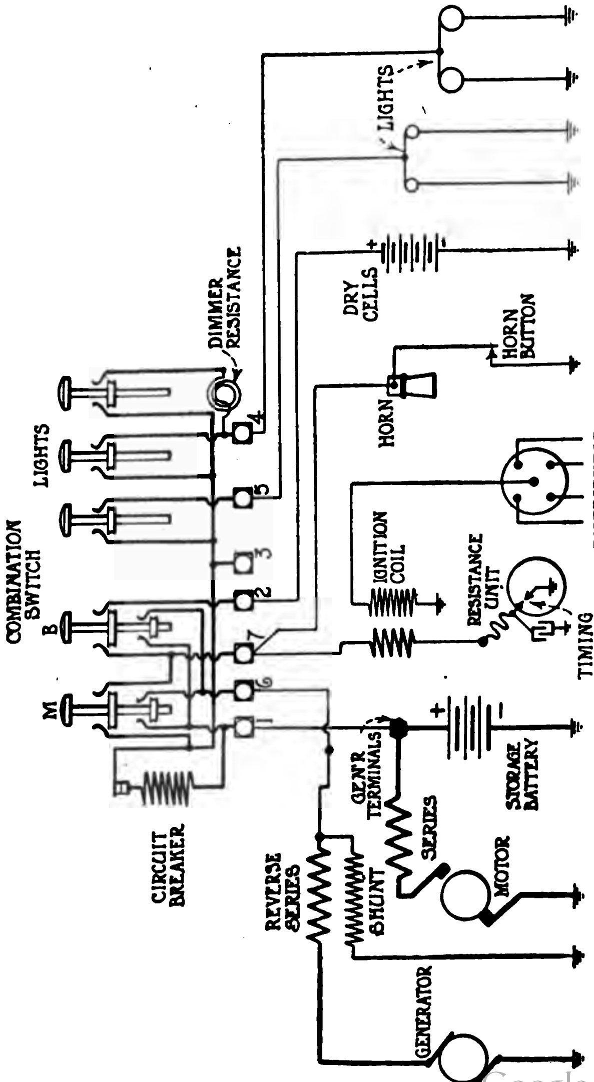


Fig. 183—*Wiring diagram of Delco installation on 1915 Cartercar model 9* to terminal point 1, through the winding of the circuit breaker, through the upper switch springs of the left switch, which now are closed, to the terminal point 8, then through the primary winding of the ignition coil through the timing contacts, the resistance unit and to ground, which completes the circuit as the negative terminal of the battery is grounded.

The second circuit closed by the button M may be traced as follows: Starting with the positive terminal of the battery to the terminal point 1, through the lower switch springs of the left switch, which are now closed, to the terminal point 7, then to the junction point of the shunt field circuit and the generator armature circuit, where the circuit divides. One path is through the generator armature through the switch above the motor brush to ground, which corresponds to the negative terminal of the battery, and the other path is through the shunt-field winding and regulating resistance to the ground connection, or negative terminal, of the battery.

As soon as the button M is depressed the generator armature acts as a motor and revolves slowly. When the starting pedal is depressed the gears connecting the armature of the electrical unit to the crankshaft of the engine are thrown into mesh, and the starting motor circuit is closed by lowering the motor brush. At the same time the motor brush is lowered, the generator armature circuit is opened. When the starting pedal is released the motor circuit immediately is opened and the generator armature circuit closed. The generator armature circuit now is connected to the terminals of the battery and will charge the battery, provided the voltage generated in the armature winding of the generator exceeds the voltage of the battery. When the engine is operated at low speeds or stopped with the button M depressed the battery voltage will exceed the generator voltage, and the battery will start to discharge through the armature and field of the generator and the generator will be acting as a motor. It will not transmit any power to the engine crankshaft as the over-running clutch connecting the two will allow the armature of the electrical unit to run ahead of the engine. The construction of the over-running clutch is such that a clicking sound will be heard when the generator is acting as a motor and serves as a warning to the driver to pull out the button M if the engine is stopped with the button depressed.

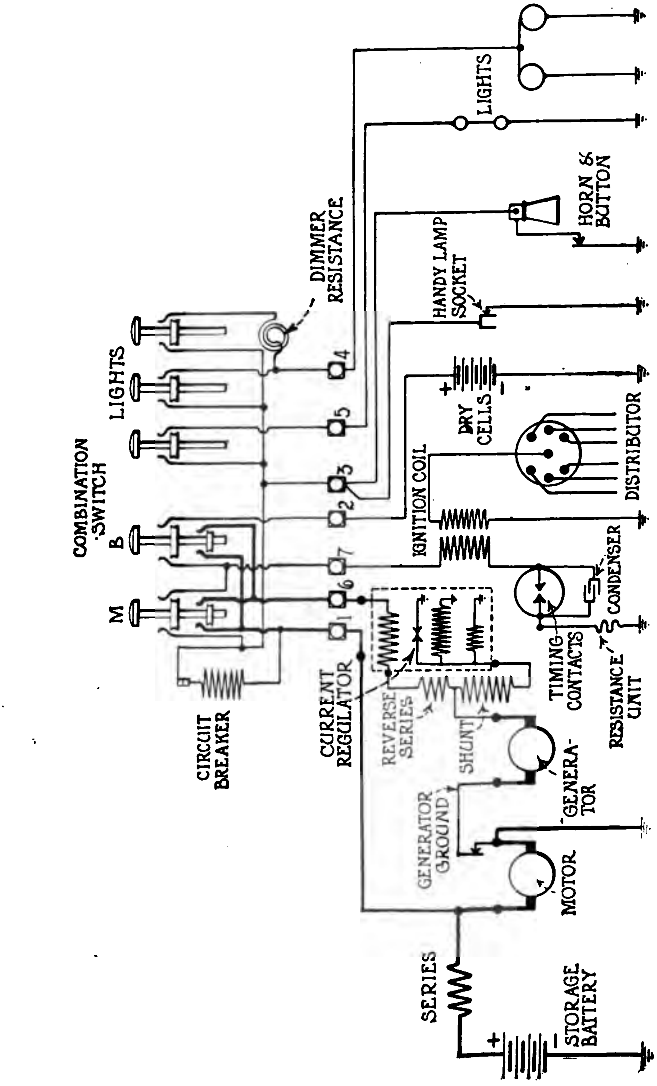


Fig. 184—*Wiring diagram of Delco installation on 1915 Cole model 4-40*

The switch B is a duplicate of the one just described. It functions in exactly the same way in connecting the generator armature terminals and the battery. When switch B is closed the ignition current is supplied by a set of dry cells instead of being obtained from the storage battery.

The switch T controls the cowl and taillights. The switch S controls the low-candlepower headlights and the switch H controls the high-candlepower headlights. All current drawn from the storage battery, except that required to operate the starting motor, passes through the circuit breaker winding, and should this current become excessive the circuit breaker immediately will operate similarly to a buzzer and thus serve as a warning that something is wrong with some part of the electrical system, due to a short, ground, or overload from some cause.

Regulation by Reversed Series Field

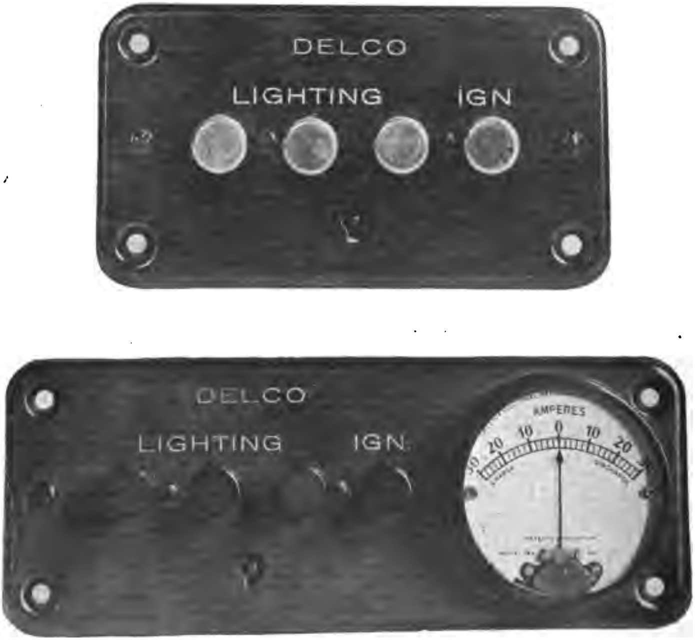
The second type of Delco 1915 equipment makes use of the reversed series-field winding for regulating the output of the electrical unit when it is operated as a generator. This system is found on 1915 Buick models 24 and 25 and on 1915 Cartercar model 9. The wiring diagram of the installation on the Cartercar is shown in Fig. 183. The electrical unit used in this installation is similar to the electrical unit used in connection with the Delco Junior system. The last switch on the right end connects the headlights to the battery with the dimmer resistance in series. If the second switch from the right end is closed, the dimmer resistance is short-circuited and the lamps are connected directly to the battery.

Regulation Combination with Current Regulator

The third type of Delco 1915 equipment used a current regulator in addition to the reversed series field. The 1915 Cole model 4-40 uses this system. A wiring diagram is shown in Fig. 184. The winding of the current regulator is connected directly in series with the lead from the positive generator brush to the terminal point 6 and carries all the current delivered by the generator. If this current exceeds a certain value, the armature of the controller is drawn up and the contact points open, which introduces a resistance in series with the shunt-field winding. This increase in shunt-field resistance causes a decrease in the field current and, hence, a decrease in the strength of the magnetic field in which the armature is rotating. This will result in a decrease in the voltage generated in the armature of the electrical unit, which will cause a reduction in the value of the current being delivered. When the current drops below a certain value the contacts will close and the output will increase in value. This cycle of operations will be repeated many times a minute, and the current actually will remain practically constant in value.

Third Brush Regulation

The output of practically all the electrical units, when operating as a generator, that were put out by the Delco company dur-



Figs. 185 *and* 186—*Delco four-button ignition and lighting switches with ammeter mounted on the same panel in the lower switch* ing 1916 and since, are regulated by the third-brush method. The construction of the electrical units for the different installations is practically the same. The chief difference is in the wiring and type of combination switch. The majority of the installations use a push-button type of switch with four push buttons instead of five. Front views of two different four-button switches are shown in Figs. 185 and 186. The only difference in the two switches is that an ammeter is provided on one and there is none on the other. The operation of this switch is practically the same as the operation of the five-button type except that a single ignition button is used and the dry batteries are done away with. The wiring diagram of a typical system of this kind is shown in Fig. 187. An ammeter is connected in the lead from the positive battery terminal to the terminal post marked 3 in the diagram. The starting motor is equipped with a brush type of starting switch, and the operation of this starting switch opens the lead from the positive generator brush to the terminal post marked 2. The generator acts as a motor when the combined starting and ignition switch is pulled out and thus assists in meshing the starting gears. This type of electrical system is used on the Auburn 6-40A, Buick D-44, 45 and D-54, 55, Buick D-4 truck, Moon models 6-30 and 6-40, Oakland 38, Oldsmobile 43 and Westcott models 41 and 51.

Six-Volt, Two-Unit, Single-Wire

The generator on the 6-volt, two-unit, single-wire Delco system is of the round-frame construction with two poles. There are two main brushes resting on the commutator and also a third brush. In some machines only one shunt coils is provided, while in others there are two shunt coils, one on each of the poles. One terminal of the machine is grounded and the remaining terminal is connected to a terminal post on the end of the machine. The shunt-field coil has one of its terminals connected to the third brush and the other end may be connected to the terminal on the machine, or in some cases it is led to the switch on the dash.

Regulation is by the third-brush method. The output of the generator is increased by moving the third brush in the direction of rotation. The adjustment of the third brush should be made carefully by an experienced person, and care should be taken to see that it seats perfectly on the commutator after its position is changed.

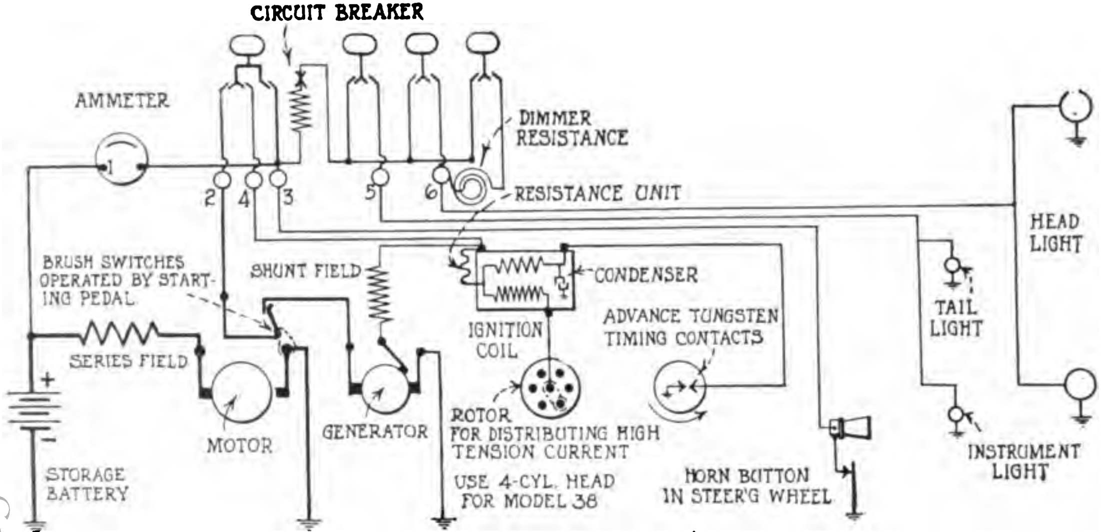

CIRCUIT BREAKER
AMMETER
1
2
4
3
5
6
DIMMER RESISTANCE
RESISTANCE UNIT
HEAD LIGHT
BRUSH SWITCHES OPERATED BY STARTING PEDAL
SHUNT FIELD
CONDENSER
SERIES FIELD
IGNITION COIL
ADVANCE TUNGSTEN TIMING CONTACTS
TAIL LIGHT
+
-
MOTOR
GENERATOR
ROTOR FOR DISTRIBUTING HIGH TENSION CURRENT
USE 4-CYL. HEAD FOR MODEL 38
STORAGE BATTERY
HORN BUTTON IN STEER'G WHEEL
INSTRUMENT LIGHT

Fig. 187—*Wiring diagram of Delco installation on* 1916 *Davis models C*-38, 6-*E and* 6-*G*

Starting Motor

The starting motor is a series-wound, four-pole, 6-volt type. The internal connections are shown diagrammatically in Fig. 188. The motor shaft is fitted with a Bendix drive, which engages with the teeth on the flywheel as soon as the armature of the motor starts to revolve. The starting switch is of the pedal-operated plunger type.

Typical Wiring Diagram

The complete wiring diagram of a system of the two-unit type as found on the 1917 Westcott cars is shown in Fig. 188. The ignition and cutout switch are combined, and the generator is connected to the terminals of the battery when the ignition switch is closed. The generator will act as a motor and its armature will revolve, as it is connected to the pump shaft by an over-running clutch. As soon as the starting switch is closed the starting motor is connected to the engine by the Bendix drive and cranks the engine, which will start to run under its own power. When the speed of the engine has increased to a sufficient value it starts to run the generator, and finally the voltage generated in the armature of the generator is greater than the voltage of the storage battery and the generator starts charging the battery.

All the various circuits, except the ignition and starting motor circuits, are protected by a circuit breaker.

Delco Ignition Systems

The Delco ignition system in its simplest form consists of a storage battery or some other source of direct current, an interrupter or breaker, with its condenser, and a transforming device such as an ignition coil. The systems manufactured in 1912, 1913 and 1914 provide for dual ignition, using the current from the storage battery or generator and also from a separate set of dry cells, although the same breaker was used for both types of ignition on the later 1914 cars. In 1915 the single ignition was adopted for use either with the storage battery or dry cells. In the case of the 1916 systems and those following, the storage battery is used for ignition, no dry cells being provided on most of the cars. The general features of the Delco ignition systems

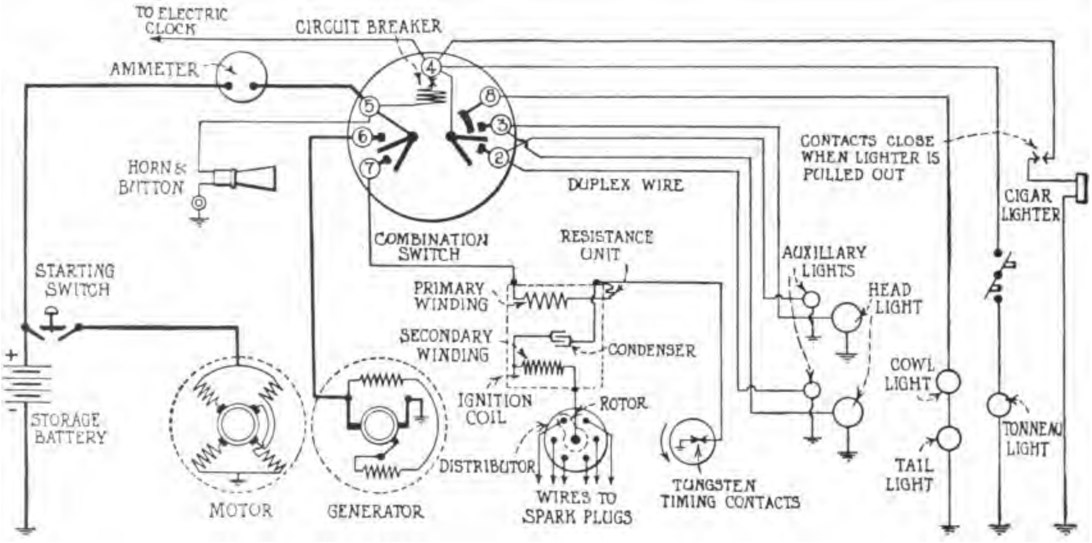


Fig. 188—*Wiring diagram of Delco installation on the Westcott series* 17 *cars* for the various years readily can be seen by reference to the wiring diagrams of the Delco electrical systems already given. The following general discussion on Delco ignition troubles and their remedies should be followed carefully by owners of this equipment and repairmen who have equipment of this make to look after. A great many of the difficulties are applicable to all ignition systems and for this reason should be given careful attention by everyone having anything to do with the electrical equipment of the motor car.

Troubles With Ignition Systems

The troubles with the Delco ignition systems are located readily, if a systematic attempt is made to properly analyze them. In the first place troubles can be divided into two general classes—low-tension and high-tension. Low-tension circuit troubles and their remedies will be considered first.

High voltage in the ignition circuit may be caused by loose connections in the circuit between the generator and storage battery or by a badly overcharged storage battery. These troubles are located very easily by measuring the voltage at the distributor and at the storage battery with a suitable voltmeter and comparing the voltage to the voltage on similar cars that are operating in a satisfactory manner. The condition of the various connections can be observed by a careful inspection of the apparatus. The condition of the storage battery can be observed by noting its specific gravity and by seeing whether the amount of distilled water required every week to keep the battery filled to the proper level is excessive or not. An excessive current may pass through the contacts if the resistance unit is short-circuited. This trouble can be tested as follows: Remove the distributor head and rotor and turn on the ''mag.'' or generator ignition, holding the contacts together firmly by hand. If the resistance unit is assembled on the distributor properly, it will heat up; if it does not heat up, it will indicate that the resistance unit is not in the circuit, and in this event it should be reassembled properly.

The effect of high voltage, whether due to loose connections in the generator circuit or to an overcharged battery, will be to permit an excessive current to pass through the timer contacts. A similar effect will be noticed if the resistance unit is short-circuited. The contacts will be burned or pitted excessively, although the ignition may appear to be very good and without a miss.

If the condenser is not in good condition, the contacts will burn and pit rapidly, due to the excessive arcing when they are separated, but the ignition will be rather bad, if indeed it will operate the motor at all, so that the burning of the contacts, due to a bad condenser, as a rule can be distinguished from burned contacts due to a high voltage or to a short-circuited resistance unit. A very good test for the condenser, with which to show whether it is in good condition or not, is to connect it up in accordance with the circuit diagram shown in Fig. 189. For this test a 110 or 220-volt source of direct current is necessary, with a lamp of the same nominal voltage as the circuit and the wiring shown. The lamp is connected in series with the line and the condenser across the line. If the terminals A and B are attached together, a very faint spark, which has a snapping sound similar to the sound made when leads from a storage battery are attached together, should occur. If the condenser be disconnected from the circuit, a much different arcing will be observed, somewhat longer and yellower and without the distinct snapping sound mentioned previously.

If a condenser, known to be good, is tested in this manner once, it will enable the observer to distinguish between the sparks at the points A and B obtained with a good condenser and a bad condenser very readily, as a bad condenser will give the same quality of spark as if no condenser at all were in the circuit. This test is a mere qualitative test, but this is about the only satisfactory test which can be found which does not require ex-

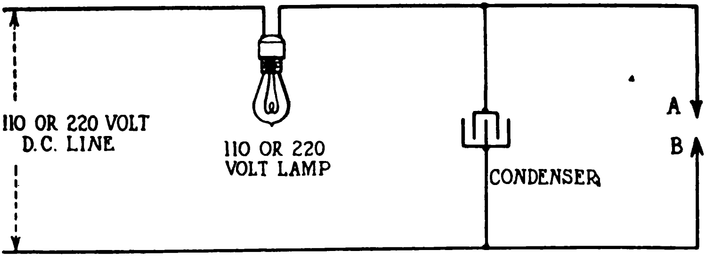


Fig. 189—*Easy method of testing a condenser* pensive apparatus. In the earlier systems the condenser was in the form of a flat oblong box, fastened to the distributor by four screws, but in a great many of the 1916 and later systems the condenser is mounted inside the black case containing the ignition coil.

In the case of all the breaker assemblies built in 1915 or earlier, particular attention must be paid to the little pigtail. If this is broken off the contact arm, the latter will tend to stick to the stud on which it moves, will permit excessive arcing at the contacts and as a rule will cause a very decided ignition miss. It will be well, therefore, to make careful examination of the contacts and make sure that they are adjusted correctly from a mechanical point of view and that this pigtail is in place, before proceeding with any of the electrical tests. The contacts consist of small disks of tungsten welded to a copper base, which in turn is welded to a support, such as a steel screw or contact arm. When the tungsten has worn away completely so that the copper is exposed on the surface of the contact, the entire contact arm or screw should be replaced.

On the 1916 type of breaker assembly with the steel timing cam, it has been found that there is a certain amount of burning of the contacts if the gap between them is too small, hence particular care should be used in setting these contacts at the proper distance before making any electrical tests. The instructions given in the various Delco instruction books on these cars go into detail and mention the gap recommended for any particular car. Reference should be made to these books, and if the information desired is not available, it will be supplied either by the motor car companies or the service department of the Delco company.

Cases where the gap appears to be different for the different lobes of the cam may be noted from time to time. This is due either to the distributor shaft being eccentric, which in turn is caused by loose or worn bearings, or due to one or more lobes on the cam being higher than the others. A thorough mechanical inspection usually will disclose where the fault lies. If the trouble lies in the bearings, they can be tightened, if of the type used in 1915 or earlier and also in the case of some of the 1916 and later machines equipped with ball bearings. In the case of the 1916 apparatus supplied with the bronze graphite bearings, a new bearing will have to be installed. If the timing cam has high lobes, these can be smoothed off slightly so as to make them even with the others. However, if the cam is too badly worn to permit of this, it will be necessary to order and install a new cam.

Another cause of trouble with the ignition system is low voltage. If the generator fails to charge for any reason, the voltage of the battery should be sufficient to take care of the ignition, but if in addition to the failure on the part of the generator to charge the battery properly, the battery itself is in such bad shape that its plates are sulphated or one or more of its cells are internally short-circuited so the terminal voltage of the battery when supplying current for the ignition is materially less than 5.2 volts, an ignition miss may occur. Also, if the ignition circuit has one or more loose connections, the voltage across the ignition circuit may be insufficient to supply the amount of current necessary for satisfactory ignition. A test of the battery by a voltmeter while the car is running, with the lights turned off and the ignition on, will make it possible to determine accurately the battery voltage under such conditions, and a careful inspection of the various connections in the ignition circuit will locate any loose or dirty ones.

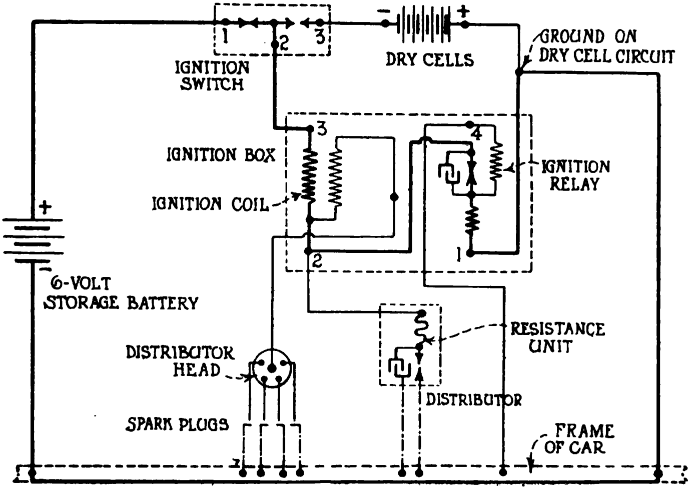


Fig. 190—Diagram showing the effect of a ground on the dry-cell circuit in the Delco ignition systems

On the 1914 systems particularly, but on any of the systems with the grounded storage battery and either the dual type of breaker, Fig. 190, or the single breaker with the dry cell circuit connected directly to one side of the coil, Fig. 191, a ground in the dry cell circuit may act as a second ground in the "mag." ignition circuit and so cause the current to flow through the primary of the coil while the timer contacts are open. This, of course, will render the ignition inoperative on the "mag." side but may have absolutely no effect on the dry cell ignition. A test for such trouble is simply to disconnect the dry cell circuit completely and note the effect on the "mag." ignition. If it removes the trouble, the ground which is causing it should be located and removed.

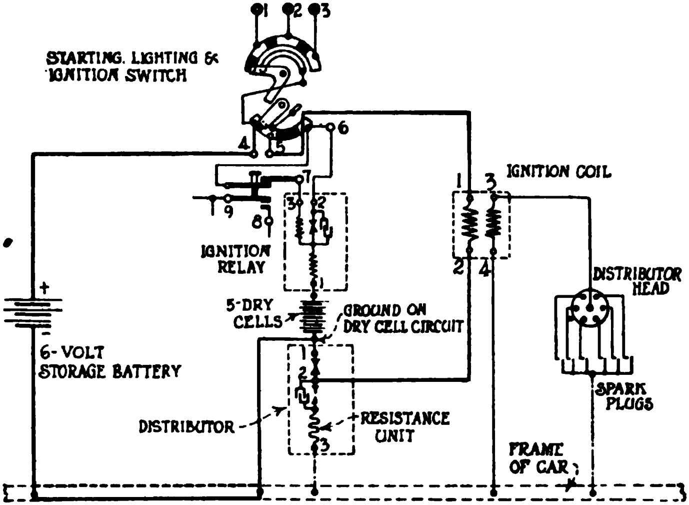


Fig. 191—*Another diagram showing the effect of a ground on the dry-cell circuit in Delco ignition systems*

The coil itself may have an open-circuited primary. If the break is clean, it of course will be impossible to get any current through the primary of the coil, but it sometimes happens that the ends of the break are touching each other so that very nearly a normal amount of current will pass through the coil while the car is standing still but the ends will be separated enough when the engine is running, due to vibration, to prevent the requisite amount of current from passing through the coil. This, of course, will cause very unsatisfactory ignition. The most satisfactory test for this particular trouble is to substitute another coil of the same type and note the effect on the ignition.

High-Tension Ignition Troubles

Leaks in the high-tension wiring permit current to jump from the high-tension wire to ground and will cause an ignition miss and may occur only at such times as accelerating while hillclimbing, or they may occur regularly and indicate that one or more cylinders are missing. The best way to locate such leaks is to run a separate wire from the distributor head to the spark plug, outside of any conduit that may be on the car, and in this way replace in turn each of the high-tension wires until the defective one is found. When found, it should be properly replaced with a new high-tension lead installed in the conduit, if there be one. Friction tape, or what is known as bicycle tape, should not be used in the insulation of a high-tension wire, as it is a very poor insulator for this purpose.

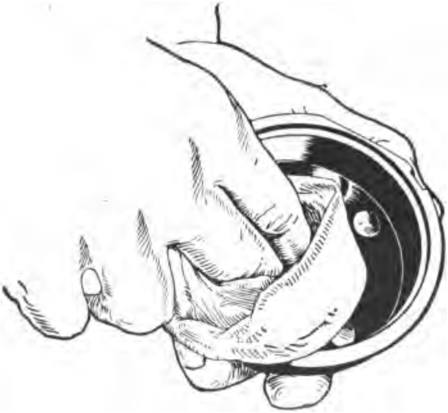


Fig. 192—Cleaning ignition head

The distributor head itself may cause trouble if the track gets sufficiently dirty to carbonize so that the spark jumps across from one terminal to another and causes pre-ignition. The most satisfactory test for such trouble is to replace the head with another head of similar model and note the effect upon the ignition. It is recommended that the track of the distributor head be kept clean with a rag slightly moistened with vaseline, to keep it polished and prevent the rotor button from sticking and thus cutting the track. See Fig. 192.

If the track appears to be cut up, the rotor should be inspected to make sure that the button is assembled with its spring properly and that the pressure of the rotor button is not too great on the distributor head. If the pressure is unduly great, due possibly to the incorrect installation of the rotor button spring, it may cause abnormal wear on the track. This is particularly true if the button gets cocked sideways. It then will tend to wear the track very badly. The rotor also may give trouble from imperfect insulation between the rotor contact and the ground, the metal distributor shaft on which it will be mounted when assembled as a part of the distributor. To test this, place it on the side of the distributor shaft and see if a spark from the ordinary ignition coil will jump to ground when held close to the rotor button contact. If the rotor insulation is sufficiently good, either no spark at all or only a very thin pale blue spark will be noted, but if the insulation is bad, a hot spark will jump to the rotor contact and thence to the ground. If the rotor insulation appears to be bad, the entire rotor should be replaced by a new one.

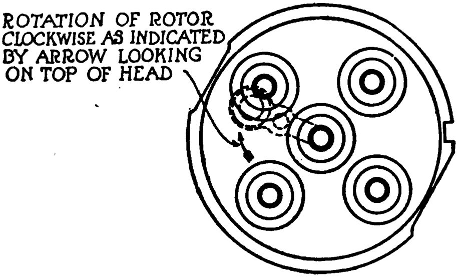


Fig. 193—*Relative positions of rotor and distributor head contacts*

The relative position of rotor contact to distributor head contact at the moment when the spark occurs may be sufficiently incorrect to permit pre-ignition. The spark, of course, occurs, in connection with the various "mag." or generator ignition systems manufactured by the Delco, when the timer contacts are just beginning to break. Therefore, the relative position of the two contacts should be considered for a given angle of advance of the spark lever, with the timer contacts just beginning to break. With No. 1 cylinder on dead center and with the timer contacts just beginning to break, when the spark lever is at a position corresponding to full retard, the rotor contact should be a third on the distributor head contact in the direction in which the rotor is revolving. This is illustrated in Fig. 193, and is approximately correct for the various systems manufactured to date. If, with the position of the timer contacts and the cylinder on dead center as before, the rotor contact is about mid-way between the distributor head terminals 1 and 3, the spark may jump to either cylinder. If it jumps to either terminal, and if it jumps to terminal No. 3, it will cause pre-ignition in the cylinder which has just completed its intake stroke. Trouble of this sort can be found only by a careful inspection of these points, and if they are found to be out, the most satisfactory way to overcome the trouble is to turn the distributor head around and set it in its proper place. This is accomplished most easily by the use of adjustable head clips, which can be obtained from Delco and put on the distributor in place of the clips regularly sent out with these distributors. An adjustment of approximately ¾ inch is obtainable with these clips, and they will take care of any case of trouble of this sort that may arise.

An open-circuited or partially short-circuited secondary in the ignition coil may cause a very weak spark. If trouble of this sort is found, as a rule it will be necessary to replace the ignition coil. By noting the strength of the spark, if it is not sufficiently great and all the preceding tests indicate that the trouble lies in the secondary of the coil itself, it will be well to test the trouble by trying a new coil of a similar type and noting the effect on the ignition. If the trouble is eliminated, the coil should be replaced permanently.

Automatic Spark Advance Mechanism

All automatic advance mechanisms put out by Delco during the various years from 1913 to the present time are driven by the distributor shaft. The amount of advance produced by the automatic governor, therefore, will be controlled by the speed of the distributor shaft, and as this is geared or driven positively from the crankshaft, it will depend upon the engine speed. Consider an automatic governor with an advance which starts to operate at 10 miles per hour and gives, say, 15 degrees advance at 25 miles per hour. In connection with the same distributor, a manual advance will be assumed, which has a total range of 30 degrees. Now, if at 25 miles per hour, the manual advance be set at 20 degrees, the total advance for the timing cam will be the sum of 15 and 20, or 35, degrees. If the manual advance were set at 10 degrees, the total advance would be 15 plus 10, or 25, degrees. In other words, at a given speed the automatic advance will be invariable and to it must be added the hand advance to get the total advance of the timing cam. It, therefore, follows that it will be necessary to adjust the manual advance lever to some extent, say for starting and for very high speeds, while for a range of from 10 to 40 miles on these particular machines, after the lever has been set to suit the requirements of the motor at any speed in this range, the automatic advance will make any necessary change to suit the driving conditions over the entire range mentioned above. The figures given are illustrative only of the general principle of the spark advance as produced by Delco and are not meant to apply in detail to any particular motor.

Another matter frequently disregarded is in seeing that the linkage that connects the spark lever to the lever operating the manual advance on the distributor is adjusted properly. These are adjusted correctly at the various motor car factories, but they may require adjustment after the car has been in service for some length of time, especially if it has been torn down and reassembled. It will be well to obtain instructions from the motor car manufacturers in regard to the details of the adjustment, and, in particular, be sure that the motion of the spark lever over the quadrant is followed by a smooth and even movement of the lever on the distributor. There should be no dead points, as this will result in too great a sensitiveness during the time the distributor lever actually is operated by the linkage. Considerable judgment is required in effecting the adjustment of these parts.

Locating Ignition Trouble

In locating ignition troubles the fact that certain other troubles may be mistaken for ignition troubles should not be lost sight of. These include particularly incorrect adjustment of the carbureters, defects in spark plugs and incorrect adjustment of the spark plug gaps, excessive oil leakage, improper valve setting, sticking valves, leaks in the intake manifold and the stoppage of gasoline supply. As these points are considered more properly under the head of engine troubles, they will not be discussed in this article, but close attention should be paid to such points when looking over the car for ignition troubles.

The exact manner of timing each particular car is a matter that should be referred to the motor car company itself.

Delco Ignition Relay

The ignition relay is connected into the dry battery circuit when used and serves to interrupt the primary ignition circuit and so produce a high-tension flow in the secondary and establish a spark at the plugs.

This relay consists of a set of contacts operated by an electromagnet with two windings, one of comparatively coarse wire, so connected that the current ceases to flow through it when the contacts are open, and the other of comparatively fine wire, connected to the contacts in such a way as to hold the armature of the relay open after the circuit in the coarse wire winding is opened at the contacts. This coil is known as the holding coil. A condenser also is connected around the contacts to suppress the arc, and thus to increase the speed with which the arc between these contacts is broken. The operation of the relay varies with the connection to the external circuit slightly.

The contacts of the relay and the series coil are in series with a special set of timer contacts on the dual distributor. When these contacts are closed by the revolving cam, current passes through the ignition coil and timer contacts and contacts of relay and through the series coil energizing the latter. This immediately causes the armature to open, thus interrupting the primary circuit and causing a spark at the spark plug. As soon as the circuit is interrupted, the series coil is de-energized and the contacts opened again. This is repeated indefinitely, giving a vibrating spark all the time the timer contacts are together. This occurs only, however, when the circuit between the terminals on the combination ignition and lighting switch is open. This is accomplished by pressing the starting button.

If it is desired to get just a single spark, the holding coil is energized, and when the armature touches the core it will be held there, so that a single spark similar to that furnished by generator or storage battery ignition will be obtained. The holding coil is energized by releasing the starting button.

In the Delco Junior system for 1914 the ignition switch completes the primary circuit, and in this manner of using the relay the holding coil circuit is completed through the timer contacts. Therefore, a vibrating spark will be obtained all the time the timer contacts are open, and the timing of this vibrating spark is obtained by the action of the contacts upon the holding coil itself. For this reason this particular method of using the relay causes a very late ignition, much later, in fact, than the method discussed in the preceding paragraphs.

Electromagnetic Cutout

The principal functions of the cutout relay, or electromagnetic cutout, as it is now known, are:

1—To complete the circuit between the generator and storage battery when the generator is running at a high enough speed to enable it to charge the storage battery.

2—To open the circuit when the speed of the generator is too low to enable it to charge the battery.

3—In the case of the Delco Junior system for 1914 only, to take the place of a starting switch. In this system it is closed mechanically by the brush shifting rod, so that the armature revolves slowly, the motor generator acting as a shunt motor, thus making it possible to mesh the starting gears.

The cutout relay consists of a set of contacts held open by spring tension and closed by an electromagnet which overcomes the tension of the spring. They should be open when the engine is at rest. The electromagnet has a compound winding consisting of a voltage coil of many turns of fine wire, which is connected across the generator terminals, and a current coil of a few turns of coarse wire, which is connected in series between the circuit of the generator and battery and is energized only when the cutout relay contacts are closed.

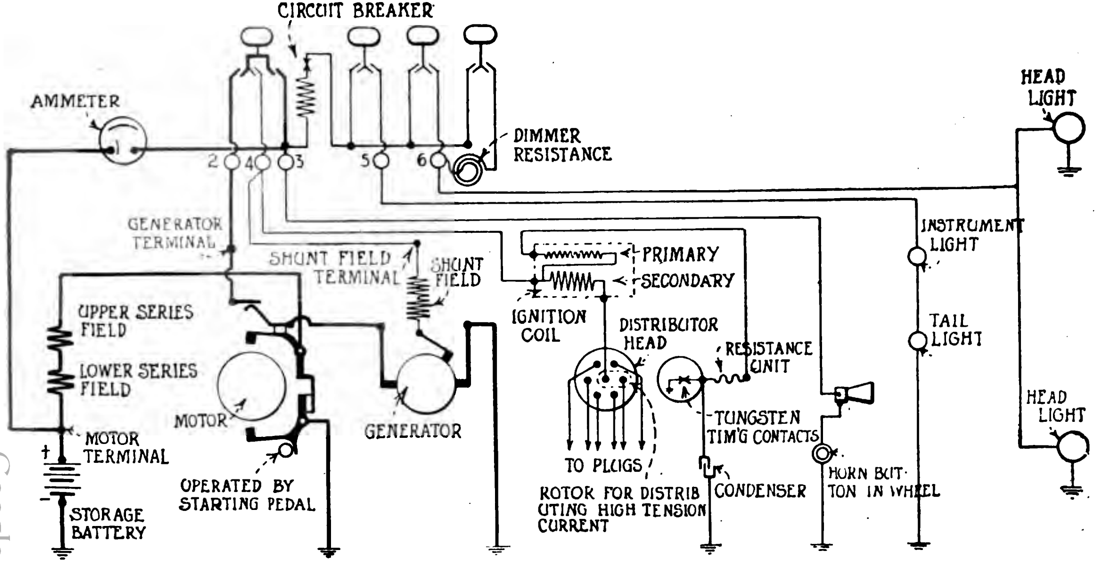


Fig. 194—Wiring diagram of the Delco installation on the Hudson Super-Six

When the engine is started the generator voltage builds up, and when it reaches a value of between 6½ and 7¾ volts, the current passes through the voltage winding and produces enough magnetism to overcome the tension of the spring attracting the armature to the core, which closes the contacts. These contacts close the circuit between the generator and storage battery. The current now flows through the current coil, producing magnetism in the core in the same direction as that produced by the voltage coil, thus strengthening the pull on the armature and holding the contacts closed.

When the generator slows down and its voltage drops below that of the storage battery, current flows from the battery to the generator in the reverse direction through the current coil. The direction of the flow of current through the voltage coil, of course, remains unchanged. The magnetism produced by the current coil now opposes that produced by the voltage coil, so the resultant magnetism is not sufficient to hold the armature closed against the tension of the spring. This causes the contacts to open, preventing any continued discharge of current from battery to generator. The relay should cut out when the discharge current reaches a value of between 0 to 1 ampere.

To adjust a relay to cut out at the proper discharge current value, two things must be kept in mind, the tension on the spring and the air gap between the armature and core.

The air gap has little or no effect upon the point of cutout, whereas the spring tension governs this almost entirely. On the other hand, the point of cutting in is governed by both air gap and spring tension. To illustrate the foregoing, four cases will be assumed:

1—Where the relay cuts in at 8 volts and cuts out when the discharge current is 2 amperes. To adjust the relay, decrease the air gap, as this will cause the cut-in point to occur at a voltage lower than 8 volts, also increasing the discharge current at the moment the relay cuts out. It will be necessary to increase the spring tension slightly to cause the relay to cut out before the discharge current exceeds one ampere.

2—Where the relay cuts in at 8 volts and cuts out with a charging current of 1 ampere, decrease the spring tension, as this will cause the relay to cut in at a lower voltage and also to cut out after the current starts to discharge through the relay.

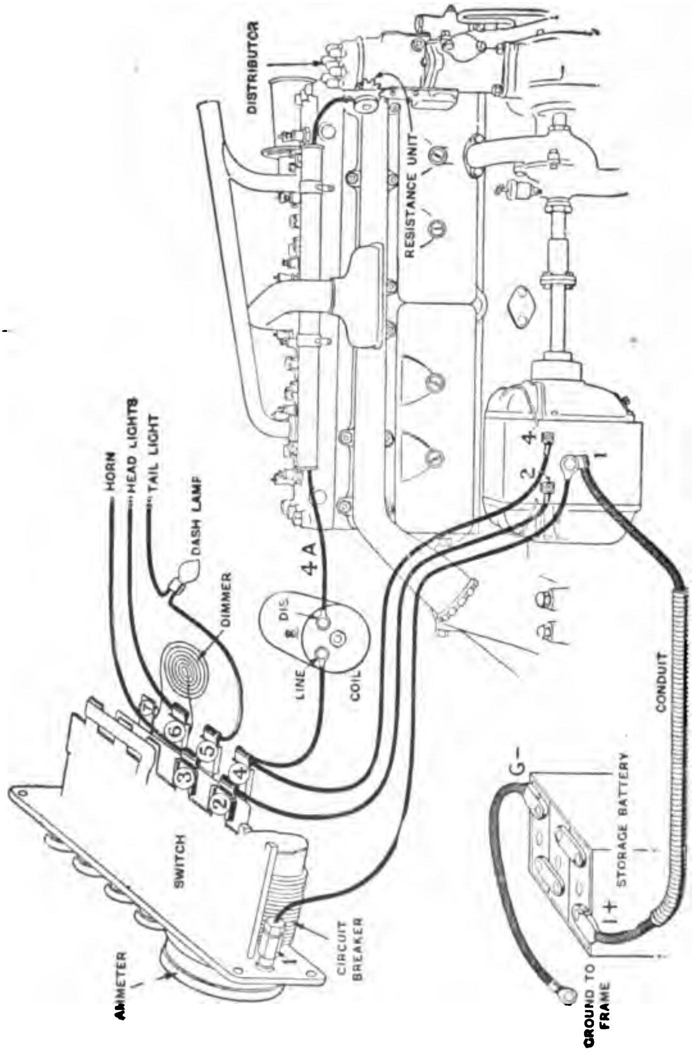


Fig. 195—*Delco Installation on Hudson Super-Six*

3—Where the relay cuts in at 6 volts and cuts out at a discharge current of 2 amperes, increase the spring tension, which will cause the relay to cut in at a higher voltage, and also to cut in at a discharge current value of less than 2 amperes.

4—Where the relay cuts in at 6 volts and cuts out with a charging current of 1 ampere passing through it, increase the air gap slightly and also increase the spring tension so as to cause the relay to cut in at a higher voltage and also cut out at a discharge current value of between 0 and 1 ampere.

The relay adjustment first should be checked for point of cut-out and cut-in. Then bearing in mind whether or not it is desired to correct the point of cut-out at the same time, the air gap or spring tension should be changed until the relay cuts in properly. As a last precaution the contacts should be inspected to make sure that they touch at the same time and all the way across.

The cutout relay is supposed to close when the voltage across the terminals of the voltage coil is between 6½ and 7¾ volts. To check this voltage, it is desirable when adjusting the relay to place a voltmeter across the terminals and make sure that the contacts close at a voltage somewhere between these values. The contacts of the cutout relay are supposed to open when the discharge current has reached a value between 0 and 1 ampere, preferably as near 0 as possible, to reduce arcing. This can be checked by placing an ammeter in the circuit in series with the current coil of the cutout relay and seeing what the value of the current is when the cutout relay opens. When properly adjusted, the air gap should be approximately $\frac{1}{32}$ inch when the contacts are closed by lightly pressing the armature with the finger.

When the relay contacts are burned or pitted, it is necessary to smooth them. This should be done with a strip of fine emery cloth, by placing the strip between the contacts, holding them lightly closed by hand, then drawing the strip of emery back and forth.

If the contacts are too badly burned, to enable them to be successfully fitted in this way it will be necessary to replace them.

After the relay has been reassembled with the new contacts, it should be adjusted in accordance with the instructions given previously.

When the contacts are adjusted correctly, both pairs will make contact at the same instant and clear across the line of contact, so that when the relay is held up to the light, it is impossible to see light passing through any portion of the line of contact.

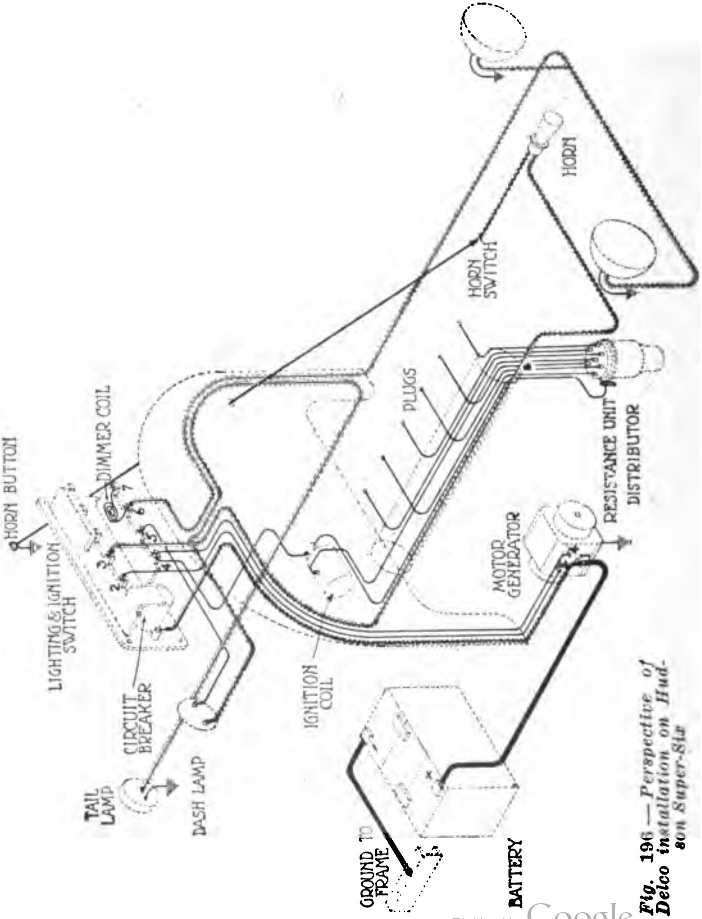


Fig. 196.—Perspective of Delco installation on Hudson Super-Six

It is also desirable when adjusting relays to make sure that all the bushings are in good condition and that the connections and coil terminals are free from grounds or breaks, as these would cause some uncertainty in the operation of the relay.

Wiring of Hudson Super-Six

Three different wiring diagrams of the Hudson Super-Six are shown in Figs. 194, 195 and 196. The system is a single-wire, 6-volt, single-unit system, with the negative side grounded.

Under normal conditions both the brushes on the motor commutator are raised, and when the starting pedal is depressed both these brushes are placed in contact with the commutator and the following circuit is established: From the positive terminal of the battery through the series windings of the motor to the upper motor brush, through the motor armature to the lower motor brush, which is grounded. The circuit is completed through the frame of the car to the negative terminal of the battery. Operating the starting pedal, in addition to moving the motor brushes, causes the motor clutch to engage with the teeth on the flywheel and with the teeth on the armature pinion.

When the ignition switch is closed the generator brushes are connected to the battery and the generator will run as a motor, which will assist in meshing the motor gears. As soon as the starting pedal is depressed the generator circuit is opened at the contacts controlled by the upper motor brush and the generator ceases to have a voltage generated in its armature winding until these contacts are closed by allowing the starting pedal to return to its normal position. The means of operation of the motor brushes is shown in Fig. 197, and a side view of the complete electrical unit is shown in Fig. 198.

The lighting circuits are protected by a circuit breaker, and the headlights are dimmed by inserting a resistance in series with them.

Wiring of Buick Models

Two wiring diagrams of the Delco electrical systems found on Buick models D-44, 45, 46 and 47 are shown in Figs. 199 and 200. The electrical unit is mounted on the right side of the engine and in front of the flywheel. It includes the starting motor and the electrical generator and carries on its forward end the electrical distributor, which is for the proper timing and distribution of the ignition current. A side view of the electrical unit is given in Figs. 201 and 202.

When the ignition switch is closed the generator acts as a motor and continues to do so until the upper brush is raised by the operation of the starting pedal, which closes the starting motor circuit by lowering the upper motor brush.

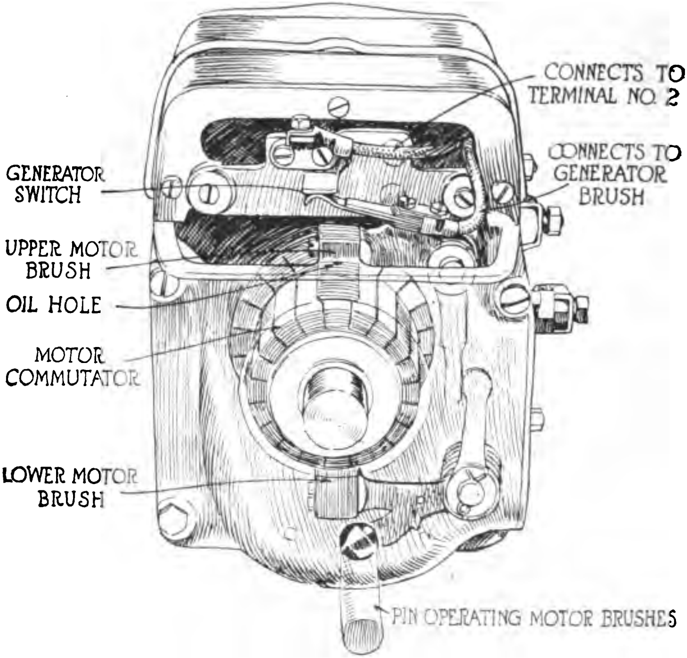

CONNECTS TO TERMINAL NO. 2
CONNECTS TO GENERATOR BRUSH
GENERATOR SWITCH
UPPER MOTOR BRUSH
OIL HOLE
MOTOR COMMUTATOR
LOWER MOTOR BRUSH
PIN OPERATING MOTOR BRUSHES

Fig. 197—*End view of Delco electrical unit used on Hudson Super-Six, showing position of motor brushes and method of raising and lowering them*

After the cranking operation is completed the starting pedal is returned by a spring, this causing the motor brush to raise from the motor commutator and the generator brush to make contact. The armature is driven by the pump shaft through the over-running generator clutch, and the generator circuit is completed through the combination switch to the storage battery. At very low speeds the voltage generated does not equal that of the storage battery, and a small amount of current is discharged through this circuit. The amount of this can be observed by watching the ammeter when the lights are off. But at normal driving speeds of the engine the voltage generated exceeds that of the battery, and current is being charged into the storage battery or used for lights or ignition or both. The ammeter is so connected that it indicates the amount of current going to or from the storage battery, with the exception of the cranking current. When the car is being operated with the lights on, the ammeter will not indicate the total output of the generator but will indicate only the amount of the output of the generator which is actually charged into the storage battery, this being the output of the generator less the ignition current and what is being used for lights. With this connection the ammeter will indicate the amount of current being discharged from the storage battery for the lights when the engine is not operating.

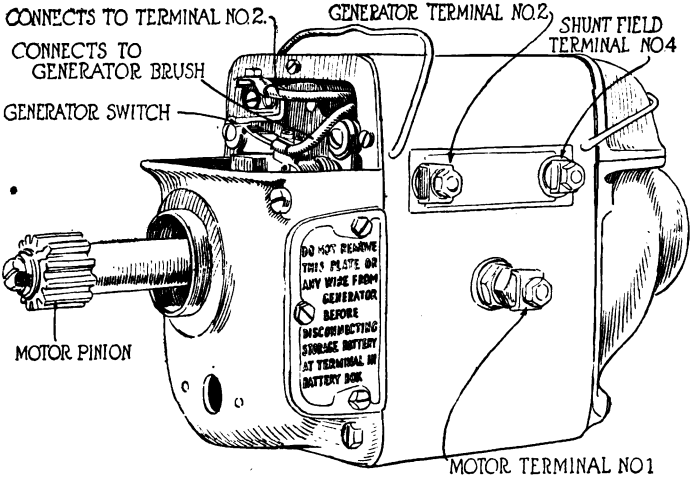

CONNECTS TO TERMINAL NO.2.
GENERATOR TERMINAL NO.2.
SHUNT FIELD TERMINAL NO.4
CONNECTS TO GENERATOR BRUSH
GENERATOR SWITCH
DO NOT REMOVE THIS PLATE OR ANY WIRE FROM GENERATOR BEFORE DISCONNECTING STORAGE BATTERY AT TERMINAL IN BATTERY BOX
MOTOR PINION
MOTOR TERMINAL NO.1

Fig. 198—*Side view of Delco electrical unit used on Hudson Super-Six*

The output of the generator is controlled by the third-brush

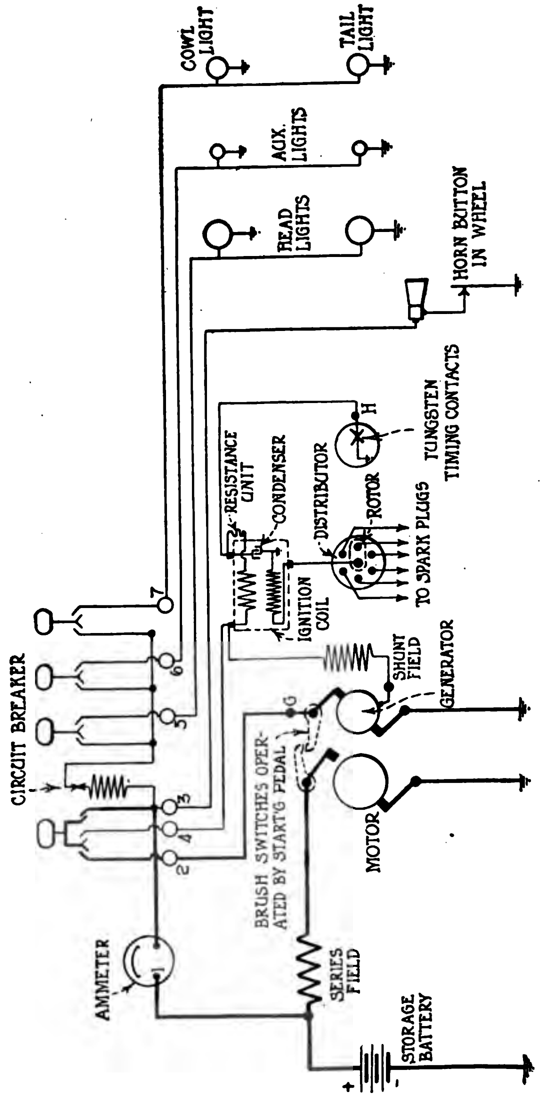


Fig. 199—*Wiring diagram of Delco installation on Buick models D-44, D-45, D-46 and D-47*

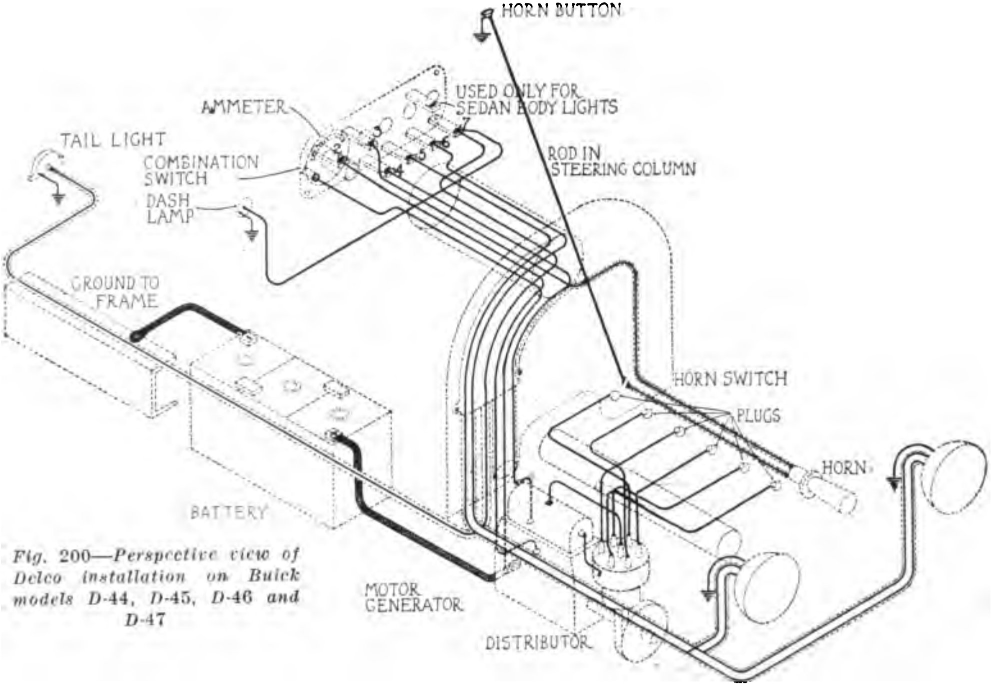


Fig. 200—Perspective view of Delco installation on Buick models D-44, D-45, D-46 and D-47

form of regulation. The electrical circuit is shown in the wiring diagram in Fig. 199. The regulation of the generator is necessary on account of the variable speeds at which it is driven, it being necessary that the generator deliver current for charging the storage battery or operating lights, horn and ignition at driving speeds corresponding to 7 or 8 miles an hour and not overcharging at the highest possible engine speeds.

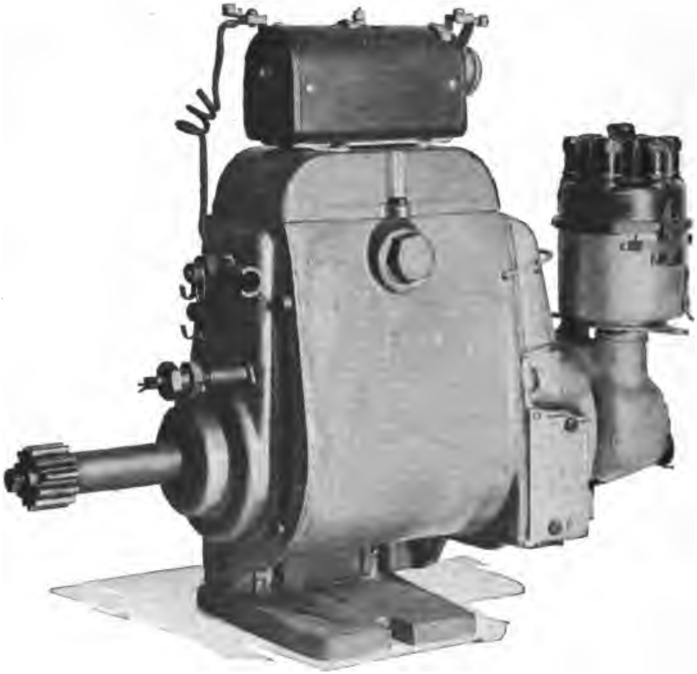


Fig. 201—*Delco starting, lighting and ignition unit used on the Buick*

Wiring of Oakland 34

Two wiring diagrams of the Delco installation on the Oakland 34 are shown in Figs. 203 and 204. This is a two-wire, 6-volt, single-wire two-unit system, the starting motor and electrical

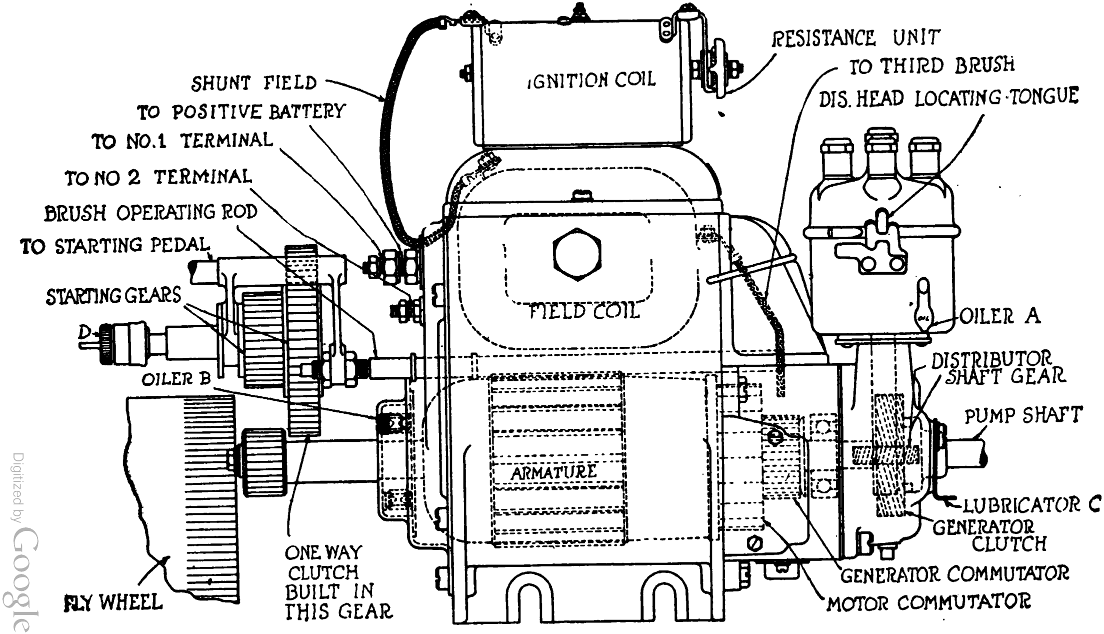


Fig. 202—Side view of Delco electrical unit showing mechanical arrangement of parts

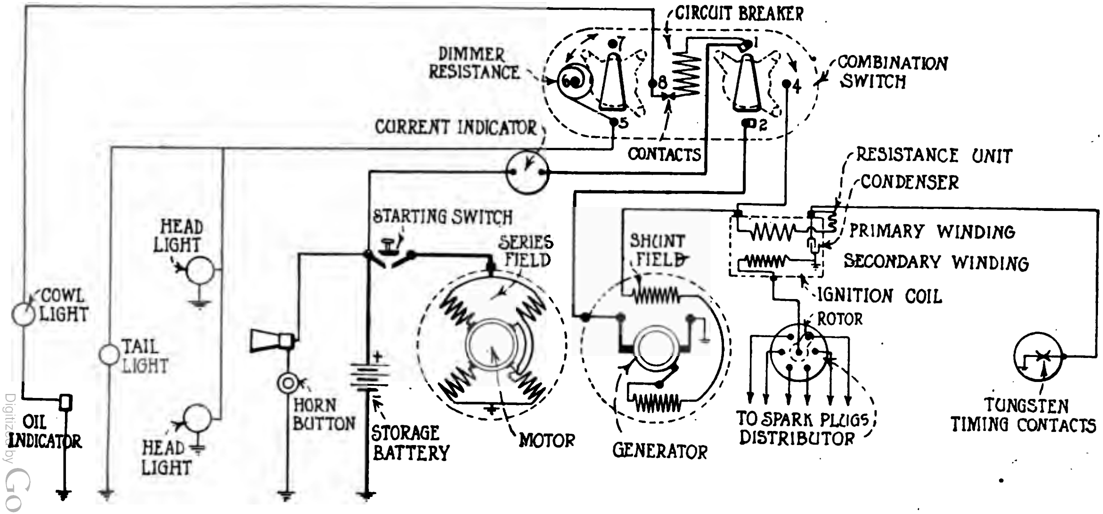


Fig. 203—*Wiring diagram of Delco installation on Oakland model 34* generator being two entirely different machines. The generator output is regulated by a third brush connected to the storage battery through a combination ignition and cutout switch as shown in the upper right corner of Fig. 203. The starting motor circuit is completed by depressing the starting switch, which causes the starting motor to start to revolve, and the Bendix drive is thrown into gear. The ammeter indicates all the current delivered by the battery except that going to the starting

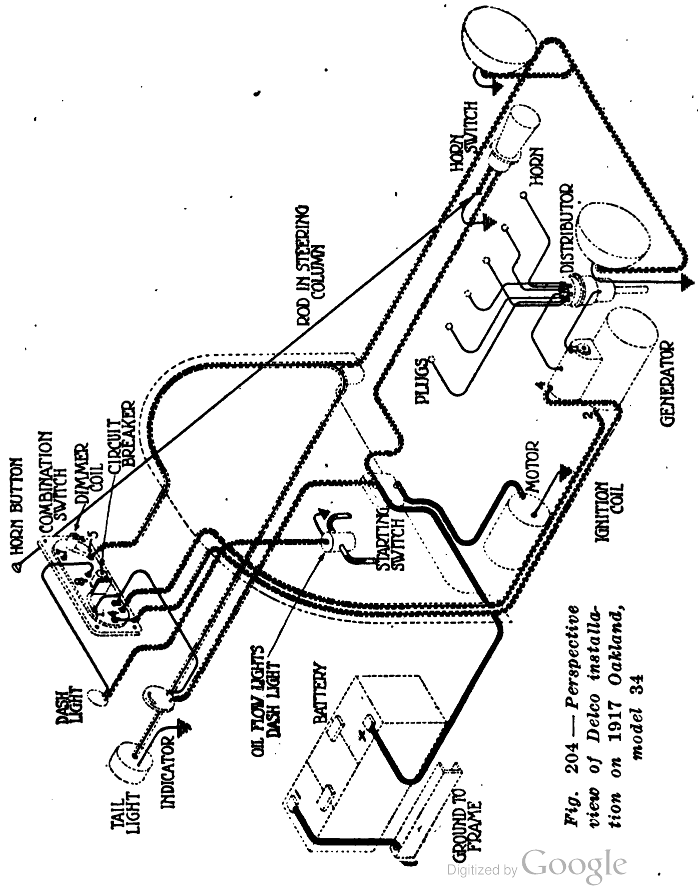


Fig. 204 — Perspective view of Delco installation on 1917 Oakland, model 34

motor and horn circuits. The lighting circuits are protected by a circuit breaker. A front view of the combined lighting and ignition switch is shown in Fig. 205.

Wiring of Cadillac 55

Two different wiring diagrams of the Delco installation on the Cadillac 55 are shown in Figs. 206 and 207. This is a single-unit, 6-volt, single-wire system. The positive side of the system is grounded to the frame of the car, and in this respect it differs from the majority of Delco systems.

The electrical unit is a bi-polar machine with a single armature core upon which are two separate and distinct windings and commutators. One winding is used for starting motor action and the other when the unit is operating as a generator. The field winding is composed of a series and shunt coil. The shunt coil is for generator action and the series coil for motor action.

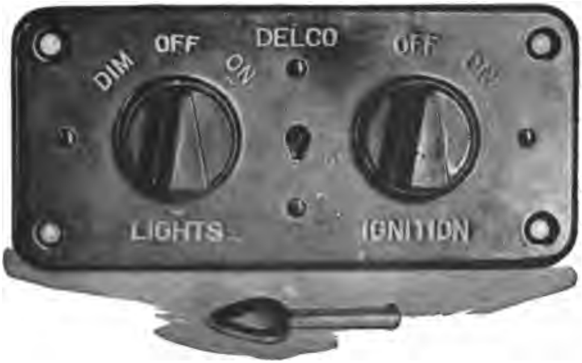


Fig. 205—One form of Delco combination ignition and lighting switch

The armature of the electrical unit, when acting as a generator, is driven at engine speed. The output of the generator is regulated by the third-brush method. The complete electrical unit is shown in Fig. 208.

When acting as a motor the sole function of the electrical unit is to crank the engine. In starting the first thing the operator does is to push down the ignition lever on the combination switch.

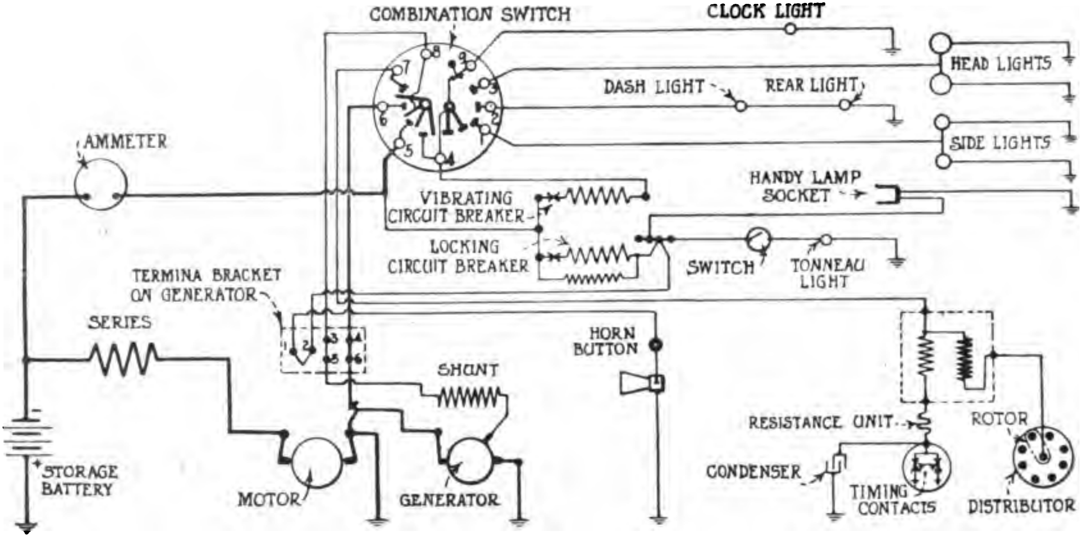


Fig. 206—*Wiring diagram of Delco installation on Cadillac* 55

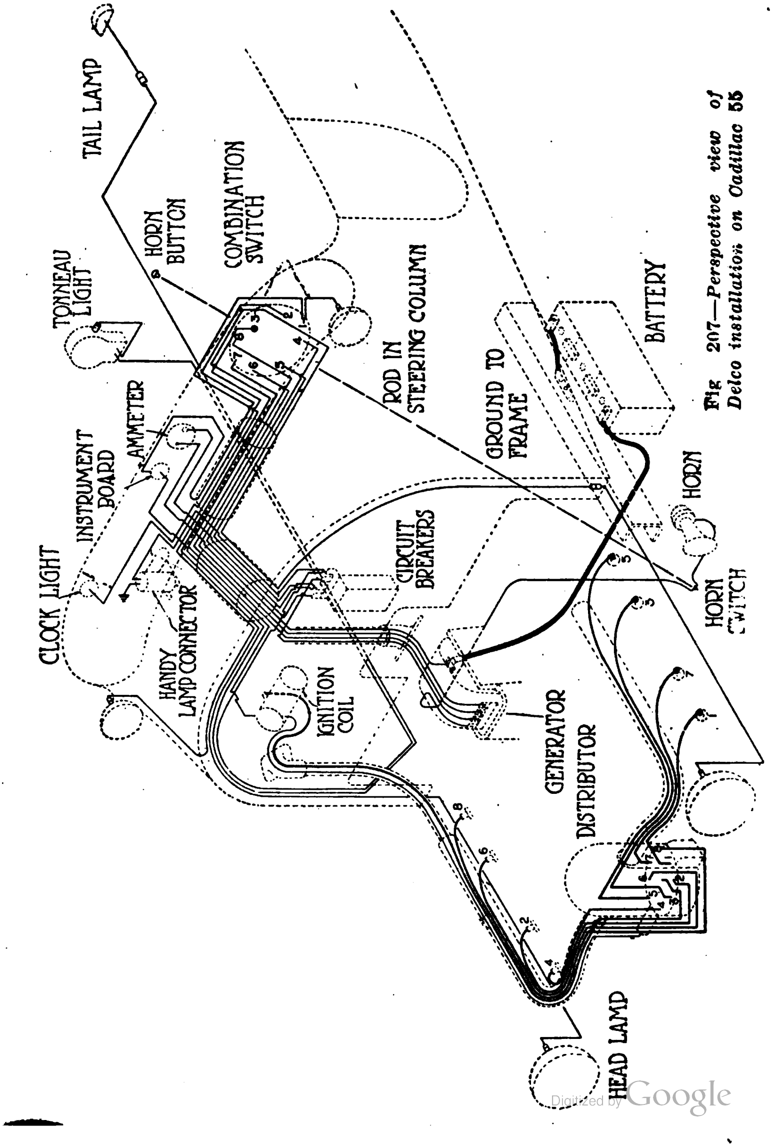


Fig 207—*Perspective view of Delco installation on Cadillac 55*

This closes the ignition circuit and the circuit between the storage battery and the generator windings on the motor generator, causing the armature to revolve slowly. A ratchet clutch in the front end of the generator allows the armature to rotate ahead of the driving shaft. The clicking noise heard when the ignition switch is turned on comes from this clutch.

Next the operator pushes down the starter button. The first movement causes the starter gears to mesh with the teeth on the flywheel. The probability of the ends of the teeth striking and failing to mesh is overcome by the slow rotation of the armature, which began as soon as the ignition was turned on. As the starter button is pushed farther down the circuit between the storage battery and the generator windings of the electrical unit is broken. Upon the last movement of the starter button the circuit is closed between the storage battery and the motor windings

Fig. 208—*Side view of Delco electrical unit used on the Cadillac* on the electrical unit, causing it to act as a powerful electric motor, which rapidly cranks the engine. As the gear ratio between the armature shaft and the crankshaft is approximately 25 to 1 the armature would be driven at an excessively high rate of speed after starting the engine and before the operator let the starter button back, if it were not for an over-running clutch in the hub of the idler gears between the flywheel and the armature shaft. The electric motor cranks the engine through this clutch, but after the engine has started and begins to run faster than the electric motor the clutch slips.

When the starter button is let up, as soon as the engine is running under its own power, the first movement of the button breaks the circuit between the electric motor and the storage battery, a further movement causes the starter gears to slide out of mesh, and the final movement completes the circuit between the generator and the storage battery, which was broken when the starter button was pushed down. The engine running and the circuit being closed between the storage battery and the generator windings of the motor generator, the generation of current begins.

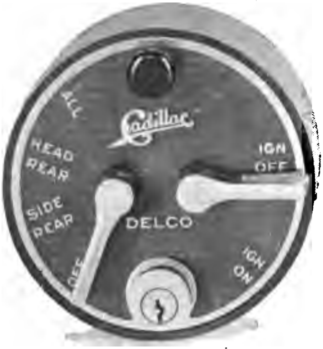


Fig. 209—*Delco combined ignition and lighting switch used on the Cadillac*

The current for ignition is controlled by the right lever on the combination switch on the instrument board. This lever also controls the generator circuit, as previously explained. A front view of the switch is shown in Fig. 209.

The distributor and timer, Fig. 210, are carried on the fan shaft housing and are driven by the fan shaft through spiral gears.

The distributor consists of a cap or stationary head of insulating material and a rotor of the same material, which turns with the timer shaft. The distributor head carries one contact in the center and eight additional contacts placed at equal distances about the center. Only two of these contacts are shown in the figure. The center contact is connected to the high-tension terminal on the ignition coil. The eight remaining contacts are connected to the spark plugs in the cylinders. The center contact is provided with a spring plunger, which is in constant communication with a plate on the rotor. This plate carries at its outer end a contact button. As the rotor revolves the contact button slides over the eight outer contacts in the distributor head, consecutively completing the high-tension circuit to each of the spark plugs from the ignition coil.

The timer, by which the low-tension current is interrupted at the proper time to produce the spark, is beneath the rotor. An eight-lobed cam on the timer shaft operates two contact arms. As the cam revolves, these arms alternately complete and break the primary circuit. The cam is held in place by a special lock screw.

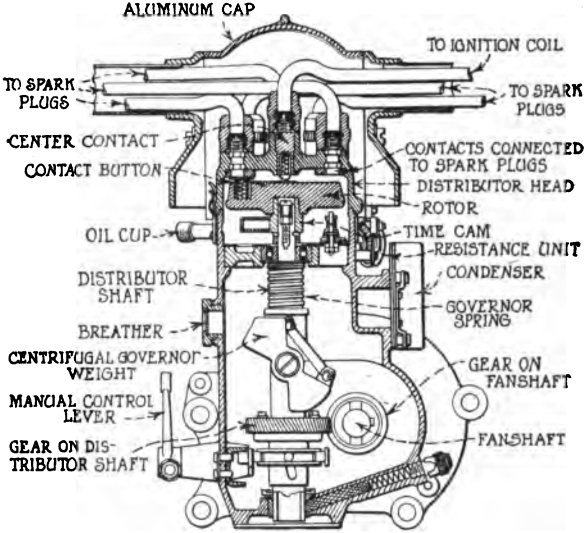


Fig. 210—Sectional view of distributor and timer used on the Cadillac

Two sets of timer contact points are provided. The object is to distribute over two sets the current which otherwise would pass through one. This greatly lessens wear and burning of the points.

The spark timing is automatically controlled by a centrifugal governor, which advances or retards the position of the timer cam relative to the driving shaft as the engine speed increases or decreases. A spark lever at the steering wheel is provided, however, by which the timing may be advanced or retarded still further. This spark lever is connected to the manual control lever at the left of the distributor housing.

Care of Starting and Lighting Units

The systems never should be operated with the storage battery disconnected, as serious injury may result. Examine from time to time all the wire connections. See that the terminal clips are well soldered, as they may become partly or completely disconnected. Clean off all oil, dirt and moisture from the terminals. Any wire exposed due to cut or worn insulation should be replaced with new wire, or the injured portion should be taped over and well shellacked. Never use aluminum paint near the terminals, as it may cause a ground or short-circuit. Inspect all bolts to see that they are tight and that the electrical unit is in proper alignment.

Inspect the commutators occasionally to see that they are clean and dry and that the brushes are fitting the surface. A good commutator surface has a smooth glossy surface, usually of a purplish color. If it is necessary at any time to sand down the commutator and brushes, be sure to remove all the grit and dust, taking particular care to clean thoroughly between the commutator segments. Then polish the surface with a piece of cheesecloth and a very small quantity of light oil.

CHAPTER XXI

North East Electrical Systems

ALL the various North East equipments, except the two-unit system, use a four-pole compound-wound motor-dynamo with a single armature and one commutator. One or both of the fields and the armature are used in both starting motor and generator actions. The various single-unit types which have been manufactured to date are designated as models A, B, D, E, F and G.

Model A Electrical System

The model A electrical unit is connected to the engine crankshaft by a silent chain and a set of intermediate gears. The gears are between the shaft of the electrical unit and the chain sprocket wheel and are carried in a gearbox which is mounted on the same bed plate as the electrical unit.

The internal connections of the electrical unit and combined electromagnetic cutout and regulator are shown in Fig. 211. The battery is composed of eight storage cells and is called a 16-volt system. A wire is connected to the center of this battery and led to the lamps so as to furnish 8 volts for the lights between this center wire and each outside wire.

The starting switch is of the type commonly known as the kick type and is mounted on the toe board within easy reach of the driver. The switch normally is held in the open position by a coiled spring. The first motion of the starting switch connects the armature of the electrical unit and the series field winding in series with the battery, and further movement of the switch short-circuits the series field winding.

When the engine starts to operate under its own power a voltage will be generated in the armature winding of the electrical unit, and when this voltage is high enough to charge the battery the circuit between the electrical unit and the battery is closed. The charging current is prevented from exceeding the normal value of approximately 7 amperes by the regulator, whose wind-

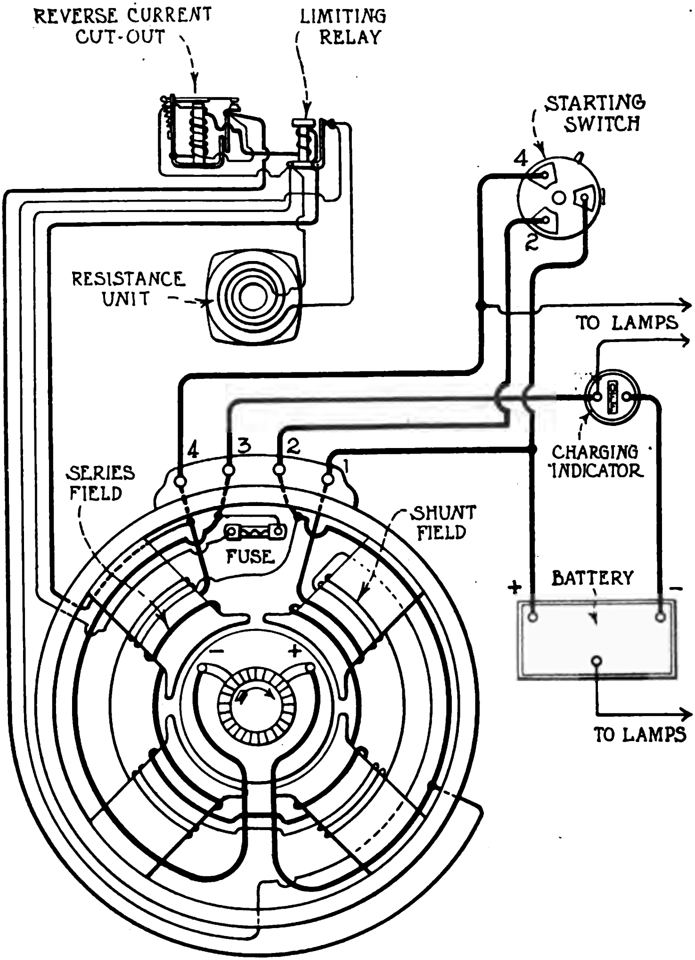


Fig. 211—*Internal connections of North East model A system with electromagnetic cutout*

ing is connected in series with the charging circuit. When the current exceeds the value for which the regulator is adjusted the armature is drawn over and a resistance introduced in the shunt-field circuit. When the charging current decreases to its proper value the contacts close and the voltage again starts to build up. This operation is repeated at a rapid rate, and the charging current is maintained practically constant. The combined cutout and regulator is located in a compartment at the drive end of the shaft, which is covered with a plate held in place by four bolts.

In the combined cutout and regulator originally manufactured a permanent magnet was used to form part of the magnetic circuit, but this type later was replaced by an improved form of combined cutout and regulator in which the cutout and regulator have independent magnetic circuits. The improved type is shown in Fig. 211. The electrical unit should not be operated with the battery removed, unless the brushes are raised from the commutator or the fuse in the shunt-field circuit is removed.

Model B Electrical System

Two types of the model B system have been made, one to be used with a 16-volt system and the other with a 24-volt system. In the case of the 16-volt system the lamps operate at 8 volts as in the previous model, while in the 24-volt system the lamps operate at 7 volts. The shaft of the electrical unit is connected to the crankshaft of the engine by a silent chain and set of gears as in the case of the model A system.

The internal connections of the electrical unit and the combined electromagnetic cutout and regulator are shown diagrammatically in Fig. 212. The starting switch is located on top of the electrical unit and is operated by an arm leading to a foot pedal on the toe board in front of the driver. The starting switch has three stationary contacts, which are short-circuited by the movable arm when the pedal is depressed. Two remain short-circuited when the pedal is released. In starting the series field and armature are connected in series with the battery and the shunt field is connected across the armature, and when the pedal is released the series field is opened.

The cutout closes the circuit between the electrical unit and the battery when the voltage generated in the armature winding is ample to charge the battery. The regulator in this model is very similar to the one used with model A.

The regulator and cutout both are located in the compartment under the commutator and covered by a pressed steel housing.

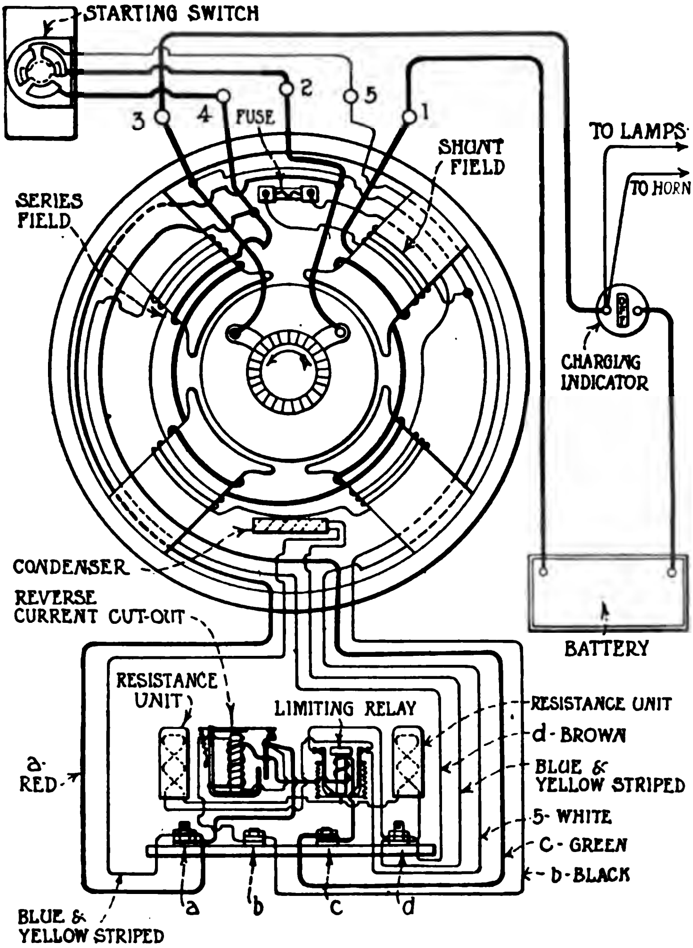


Fig. 212—Internal connections of North East model B system

The electrical unit should not be operated with the battery disconnected, unless the brushes are raised from the commutator or the fuse is removed from the shunt-field circuit.

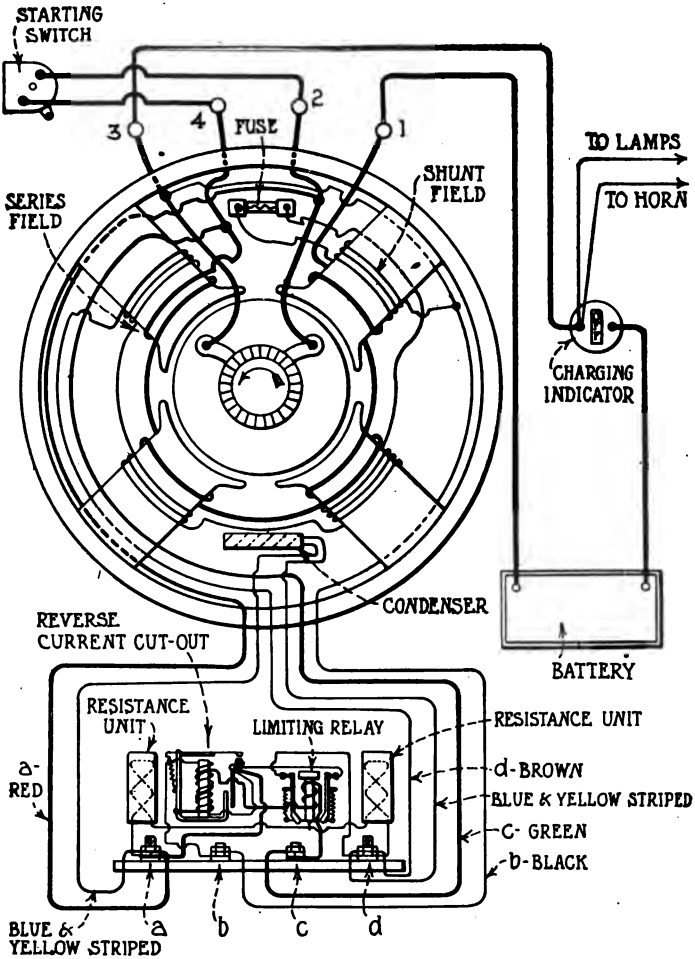


Fig. 213—Internal connections of North East model D system

North East Models D, E and F

These three models are practically identical in their construction, connections and operations. In some cases a 24-volt system

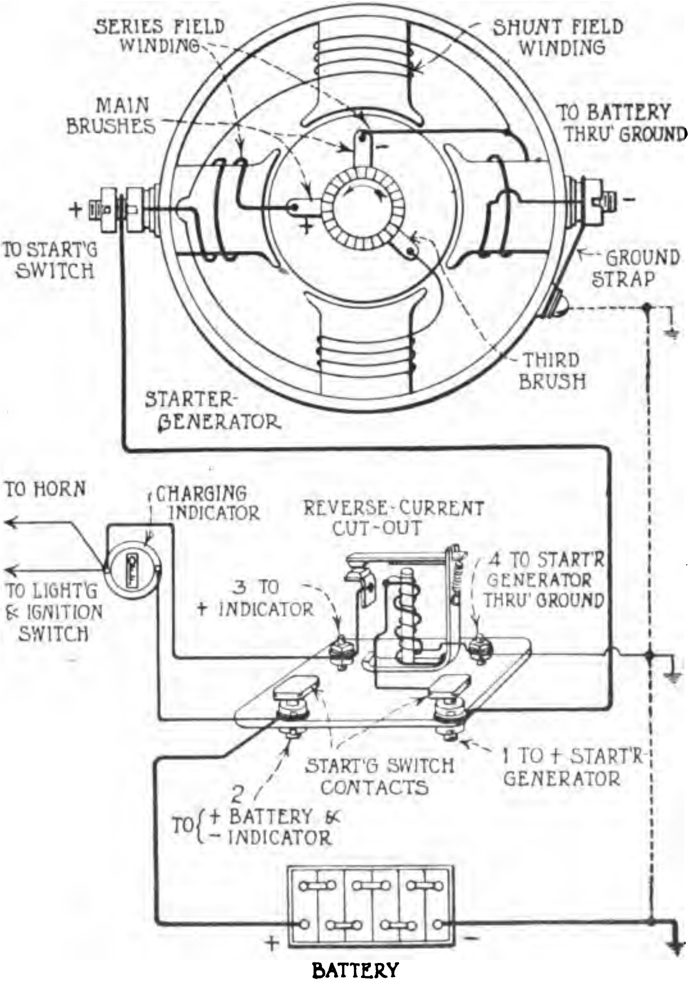


Fig. 214—*Internal connections of North East model G system, with type* 3554 *electrical unit and type* 8100 *combined starting switch and cut-out*

is employed, while in others a 12-volt system is used. The lights are operated on 6 volts in the case of the 24-volt system and on

12 volts in the case of the 12-volt system. The internal connections of the model D system, with binding post terminals and the combined cutout and regulator, are shown in Fig. 213.

The starting switch is located under the toe board within easy reach of the driver. Closing the starting switch connects the armature and series fields in series with the battery, with the shunt field winding connected across the armature terminals. When the voltage of the generator has reached a sufficient value to charge the battery the cutout contacts close and connect the electrical unit to the battery. The output of the electrical unit is regulated by the same method as used with models A and B.

The tension in the driving chain is adjusted by an eccentric adjusting ring in the front flange of the cylinder block. This ring fits over the forward end of the electrical unit. The unit is supported by two adjustable V blocks and held in position by a steel strap. There should be about ½ inch up and down movement in the chain.

Model G Electrical System

This system uses 12 volts throughout, the battery being composed of six cells. The internal connections of the electrical unit and the combined cutout and regulator of one of the earlier model G systems are shown in Fig. 214. In this system the starting switch is placed in the same housing with the cutout and regulator and mounted under the toe board in front of the driver. The starting switch is closed by depressing a pedal that extends up through the toe board. When the starting switch is closed the electrical unit operates as a cumulative compound motor.

As soon as the engine is running at a speed equivalent to approximately 10 miles per hour the cutout will close and the generator will start to charge the battery. The output of the generator is maintained at the correct value by the joint action of the third-brush type of regulation and the differential action of the series field winding.

A more recent type of the model G system is shown in Fig. 220. In this case there is a shunt field coil on each of the four poles and also a series coil on each pole. In the earlier models two poles had shunt coils and two had series coils.

North East Two-Unit System

The generator for the North East two-unit, single-wire, 6-volt system is a bi-polar shunt-wound machine and may be driven

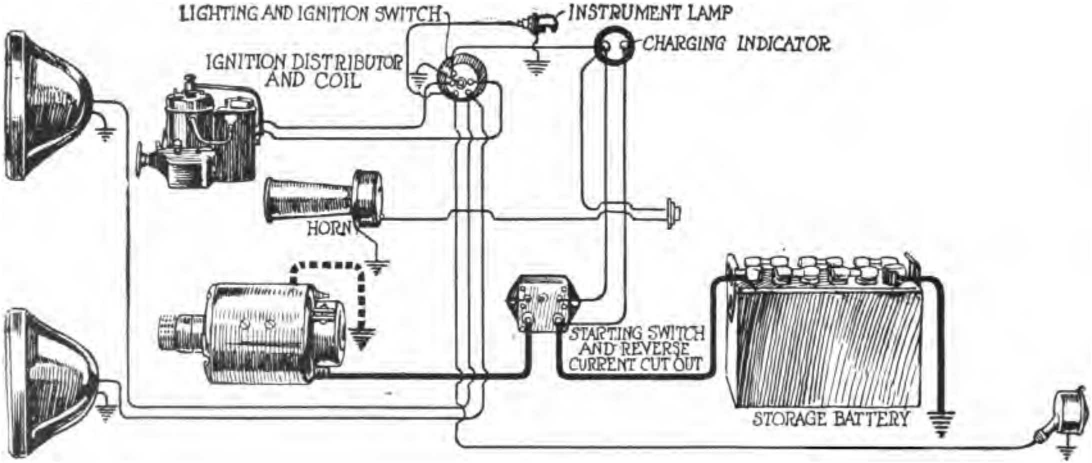

LIGHTING AND IGNITION SWITCH
INSTRUMENT LAMP
CHARGING INDICATOR
IGNITION DISTRIBUTOR AND COIL
HORN
STARTING SWITCH AND REVERSE CURRENT CUT OUT
STORAGE BATTERY

Fig. 215—*Wiring diagram of model G 12-volt North East system as applied to the* 1917 *Dodge Brothers car* through a flexible coupling from the pump shaft or, if that is impracticable, through gears or through a silent chain from the engine crankshaft. Other methods of driving may be used as conditions demand.

The output of the generator is operated by the third-brush type of regulation and so designed that it will permit the maximum charging rate to be reached at a rather low speed.

Starting Motor

The starting motor is a four-pole series-wound machine capable of developing more than 1 horsepower at a rated voltage of 6 volts. The mechanical connection between the starting motor and the engine is taken care of by a Bendix drive.

The starting switch and electromagnetic cutout for the two-unit system are mounted in the same housing, and their construction and operation are practically the same as similar North East devices already described.

System on 1917 Dodge Brothers Car

Two wiring diagrams of the North East electrical installation on the 1917 Dodge Brothers car are shown in Figs. 215 and 216. The system is a single-wire, 12-volt, single-unit type with the negative side grounded. The electrical unit is a model G type. It is driven at three times engine speed by a silent chain running over a sprocket keyed on the front end of the crankshaft and another sprocket fastened to the shaft of the electrical unit. The armature is supported in ball bearings at both ends.

The chain adjustment is taken care of by an eccentric ring on the front end of the electrical unit, which fits in an opening in the flange of the cylinder block. The starting switch, cutout and regulator all are combined in one housing and mounted on the under side of the toe board.

The charging indicator is located on the left side of the instrument board and is inserted in the charging circuit between the automatic cutout and the positive battery connection. To the positive terminal on the charging indicator are connected the wires which conduct the current for the ignition and lighting switch and for the horn. This indicator registers "charge" when the starter-generator is charging the battery and "discharge" when the battery is supplying current for the ignition or lighting systems. Whenever the starter-generator is supplying current

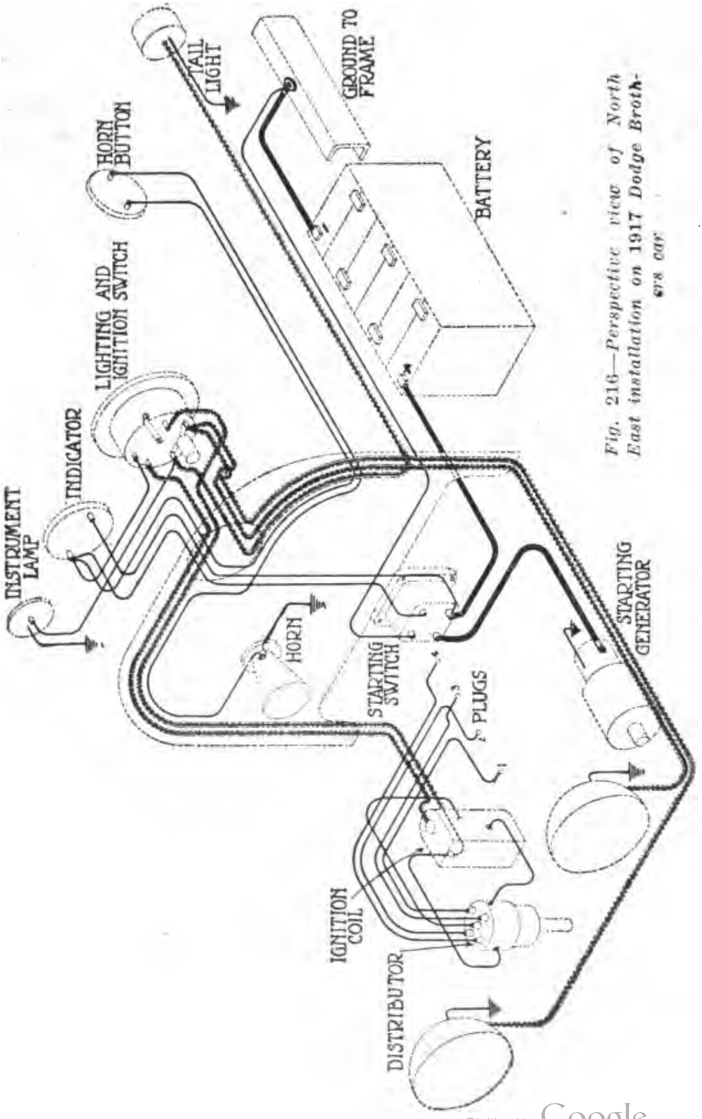


Fig. 216—*Perspective view of North East installation on* 1917 *Dodge Brothers car* to the battery, however, the indicator will show charge even if all the lamps are burning. "Discharge" will appear on the indicator whenever the lights are being used while the car is standing or running on direct drive at a speed of less than 10 to 12 miles per hour.

If at any time the charging indicator fails to register properly, inspect its terminal posts to see that the wires leading thereto are attached securely. Also make sure that there are no short-circuits in the wiring system. The showing of discharge instead of charge, when the latter should be indicated, is an almost certain sign that a short-circuit has developed in the wiring system unless, of course, the wires attached to the charging indicator have been connected to its terminals in such a way as to reverse the direction of flow of the current through the indicator. If no short-circuit in the car wiring is to be found, then the indicator may be in need of repair. Be sure to replace properly all connections before running the engine.

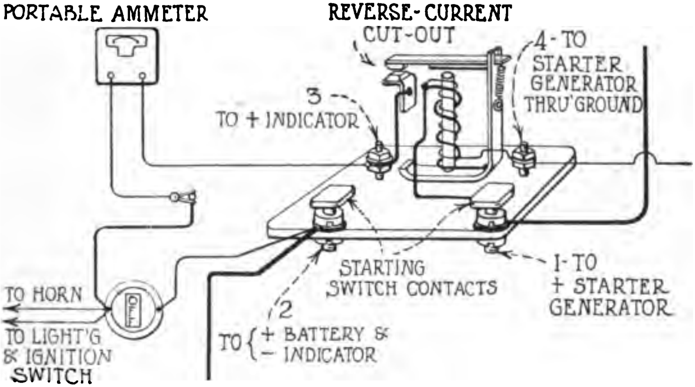


Fig. 217—*Method of connecting portable ammeter in the charging circuit of the North East system*

Should the charging indicator be removed from the circuit, connect together all the leads which normally are attached to its terminals. Failure to do this will injure the equipment if the engine is operated.

The lighting system is of the ground-return type, the car frame

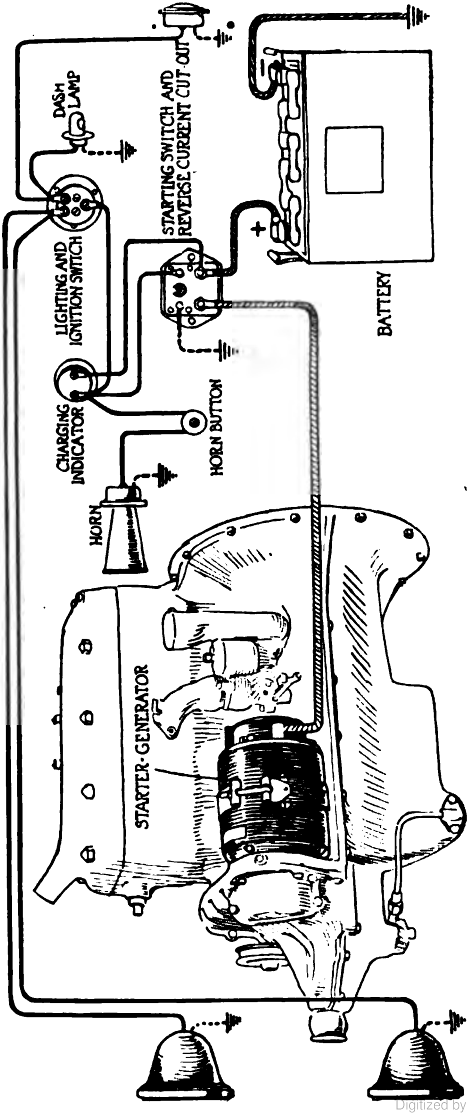

DASH LAMP
STARTING SWITCH AND REVERSE CURRENT CUT-OUT
LIGHTING AND IGNITION SWITCH
+
BATTERY
CHARGING INDICATOR
HORN BUTTON
HORN
STARTER-GENERATOR

Fig. 218—North East model G starting and lighting system as applied to the 1918 Dodge Brothers car

serving as a return path for the current from the lamps to the negative terminal of the battery.

There are two headlamps, a dashlamp and a taillamp. The lamp bulbs used are as follows:

Headlamps—15-candlepower, 14 volts, G-16½ bulb, single-contact, bayonet base.

Taillamp—2-candlepower, 16 volts, G-6 bulb, single-contact, bayonet base.

Dashlamp—2-candlepower, 16 volts, G-6 bulb, single-contact, bayonet base.

The lighting switch has three positions—"Off," "Dim," "On." In the "Dim" position the tail lamp, the dash lamp and the head lamps "dim" are turned on. In the "On" position the tail lamp, the dash lamps and the head lamps "bright" are turned on. On the back of this switch is located the dimmer resistance coil through which the current for the head lamps flows when the switch handle is turned to the "Dim" position. All the lamps are connected in parallel so the burning out or removal of any one of them will not affect the others.

The best results will be obtained from the head lamps when the bulbs are in focus with the lamp reflectors.

To obtain the proper focus place the car in position where the light can be projected on a wall, about 100 feet from the car. Adjust the bulbs backward and forward until the illumination on the wall is most brilliant and free from black rings and streaks. The bulb sockets are held in place by corrugations in the lamp sockets and will remain in proper position when once adjusted. Focus each lamp separately. See that the lamp brackets are set so that the light is projected straight ahead.

The battery should receive frequent inspection and should be filled with pure water to the proper height whenever necessary. In case any part of the electrical system fails to work satisfactorily, test the battery with a hydrometer and if it is found to be in a discharge condition, inspect the entire system for short-circuits or loose connections. If in so doing the ground wire of the starting switch or the indicator wires are removed, care should be taken to replace these wires properly before again starting the engine. The owner should not attempt any repairs himself or allow inexperienced electricians to tamper with the electrical equipment but in general should consult the Dodge Brothers dealer

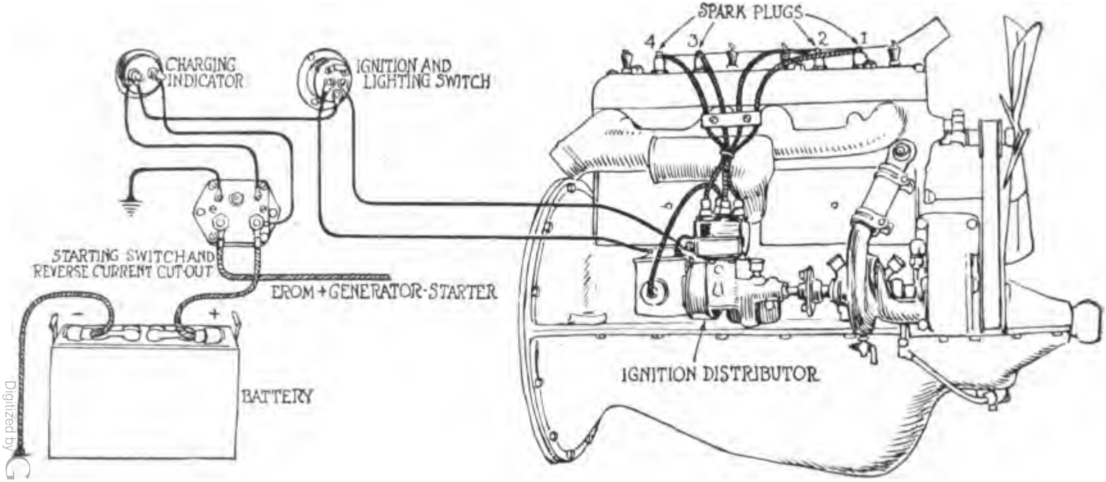


Fig. 219—*Model O Delco ignition system as applied to the 1918 Dodge Brothers car*

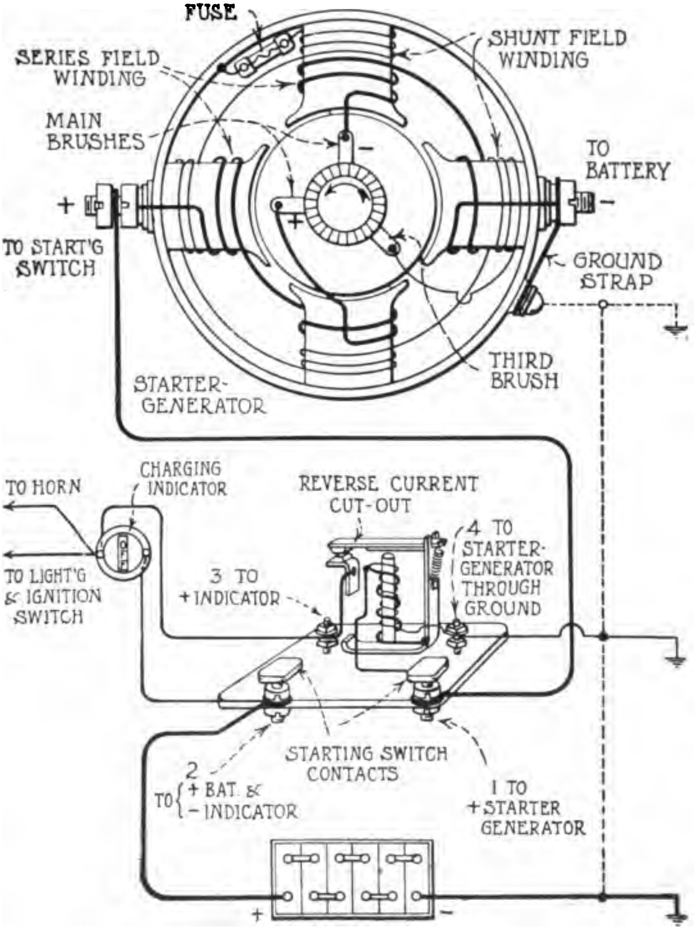


Fig. 220—Internal connections of North East model G starting and lighting system, with type 3566 *electrical unit and type* 8100 *starting switch and cutout*

or the North East Electric Co. or one of its branches or service stations.

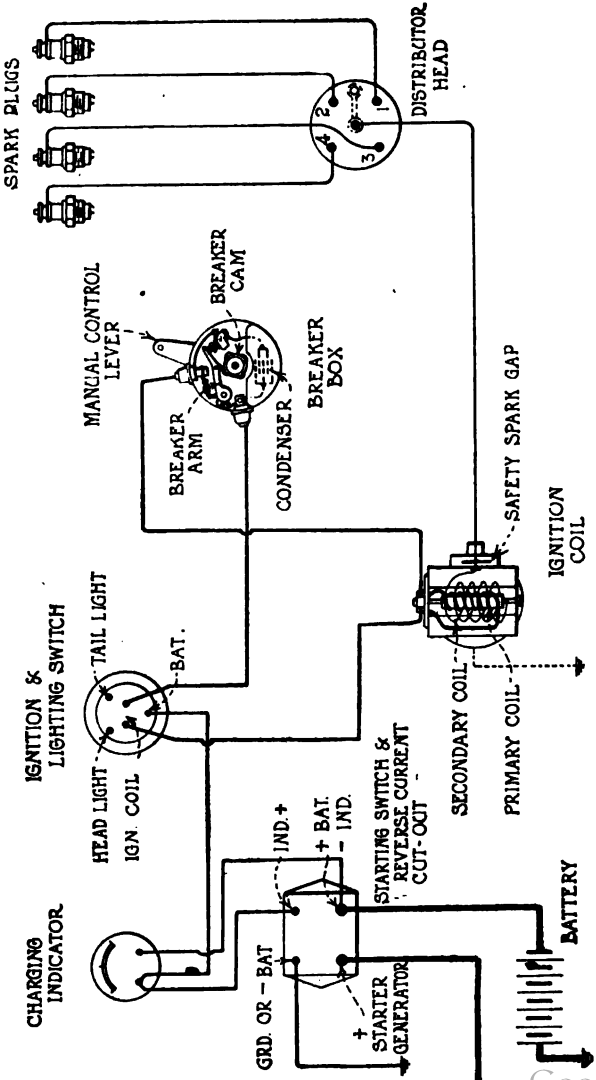


Fig. 221—*Wiring diagram of the Delco model O ignition system on the* 1918 *Dodge Brothers car*

A portable ammeter may be connected in series with the charging indicator as shown in Fig. 217 and a check made on the charging rate of the electrical unit at different speeds. An ammeter should be used always when making any changes in the position or adjustment of the third brush.

The electrical unit must never be run with the battery disconnected from the circuit. This is a condition which endangers the coils, brushes and commutator of the electrical unit as well as the windings of the reverse current cutout. The reason for this is that the battery forms an important link in the starter-generator control system, and its removal from the circuit invariably impairs the effectiveness of the remainder of the control system. Therefore, whenever the occasion arises necessitating the operation of the system without the battery in circuit, the positive terminal of the electrical unit must be grounded or connected directly to the negative terminal of the electrical unit.

With the battery removed from the car, however, it will not be possible to operate the engine, except when it is equipped with magneto ignition, unless some other source of current for the ignition system is provided temporarily.

The fuse located on the outside of the commutator-end housing of the type 3554-G-1 electrical unit is inserted in the shunt-field circuit and is designed to blow if the battery circuit is opened, thus protecting the system by rendering the electrical unit inoperative. Therefore, if the machine fails to charge the battery at any time, inspect the fuse first of all, and in case it is found blown replace it with a new one. If the new fuse in turn blows as soon as the machine is started up, make a careful search for the cause of the trouble and see that conditions are corrected before allowing the equipment to go into service again.

The fuse used should not be larger than 12-ampere capacity or smaller than 10-ampere capacity.

System on 1918 Dodge Brothers Car

The electrical installation on the 1918 Dodge Brothers car is practically the same as that used on the 1917 model. A wiring diagram of the starting and lighting system is shown in Fig. 218. The internal connections of the electrical unit and the combined cutout, regulator and starting switch are shown in Fig. 220. The ignition system is shown in Fig. 219. The internal connections of the ignition system, which is made by the Delco company, are shown in Fig. 221.

As will be evident upon reference to the wiring diagram, the primary circuit of the ignition system leads from the positive terminal of the battery through the charging indicator to the ignition switch binding post marked ''Bat.''; thence, when the switch is turned on, through the switch to one of its binding posts marked ''Ign. Coil.'' Continuing on from this point through the ignition coil and the breaker contacts, it returns to the second switch binding post marked ''Ign. Coil,'' whence it passes through the switch again, and then finally reaches the grounded negative terminal of the battery through the grounded terminal of the switch and the car frame. The ignition switch is so constructed that it produces a reversal of polarity in the distributor circuit each time the switch is turned off and then on again. For this reason there is no necessity for making a distinction between the two wires leading from the distributor to the two switch binding posts marked ''Ign. Coil,'' because the operation of the system cannot be affected by the transposition of these wires. With this one exception, however, the ignition circuit connections always must be made exactly as indicated in the diagrams, if a satisfactory operation of the system is to be obtained.

CHAPTER XXII

Wagner Electrical Equipment for Motor Cars

A 12-VOLT combined generator and motor was used in the early model of the Wagner single-unit, two-wire system on the 1913 Studebaker 35 and six cars. The machine has four poles, and each pole is provided with a shunt and series winding. The armature of the machine has two independent windings and, therefore, two commutators. The armature of the electrical unit is driven direct from the engine through a set of spur gears when it is operating as a generator. When the electrical unit is operating as a starting motor the armature is connected to the crankshaft of the engine by a special planetary gear.

The starting switch is of the drum type. It is mounted on top of the electrical unit and operated by a rod which extends through the dash of the car and terminates in a handle within easy reach of the driver. The lever operating the starting switch also controls the friction band which puts the planetary gear into operation.

The regulation of the generator output is accomplished by the third-brush type of regulation in combination with a reversed series field.

The cutout is of the electromagnetic type and automatically connects the generator to the battery, when the generator voltage is high enough to charge the battery, and disconnects the two when the battery starts to discharge through the generator due to the voltage of the generator being lower than the voltage of the battery.

A wiring diagram of this system is shown in Fig. 222. When the starting switch is thrown to the starting position the full 12 volts of the battery are used, and when the switch is thrown to the running position it permits the use of a 6-volt lighting system and a three-wire arrangement of the electrical system.

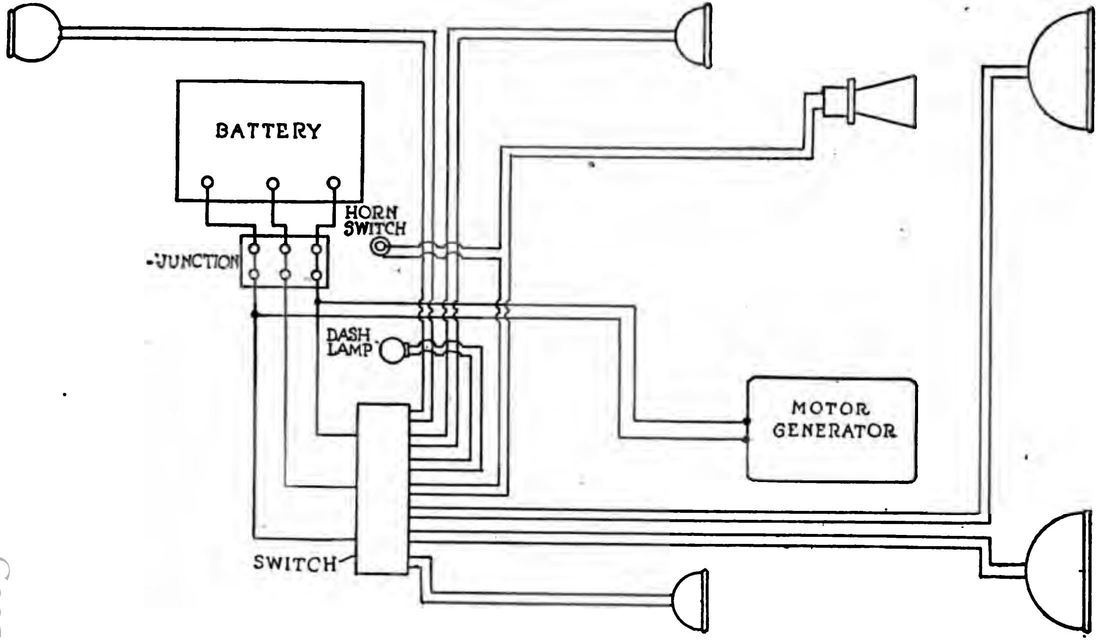


Fig. 222—*Wiring diagram of Wagner system used on the 1913 Studebaker cars*

If the starting and generating circuits are traced carefully, it will be found that the armatures are in parallel for motor action and the magnetic field is produced by the series coil, while for generator action the armatures are in series and half the shunt field is connected across each armature.

A wire is run from the center of the battery to the lighting switch, and the lamps are operated on a three-wire system, half the battery voltage being applied to any one lamp.

Wagner 1914 Two-Unit System

The starting motor in the Wagner 12-volt, two-unit, two- and three-wire systems of 1914 is a four-pole series-wound type equipped with a gear reduction for reducing the speed of the engine in relation to the speed of the motor so it will be suitable for cranking the engine. An end view of the starter and gear with the gear-housing cover removed is shown in Fig. 223. The gear equipment consists of a small steel pinion, A, on the motor shaft which meshes with a larger steel gear, B, on the back shaft, thereby reducing the speed. The back shaft is equipped with an over-running clutch which locks when the engine is being cranked and releases as soon as the engine fires.

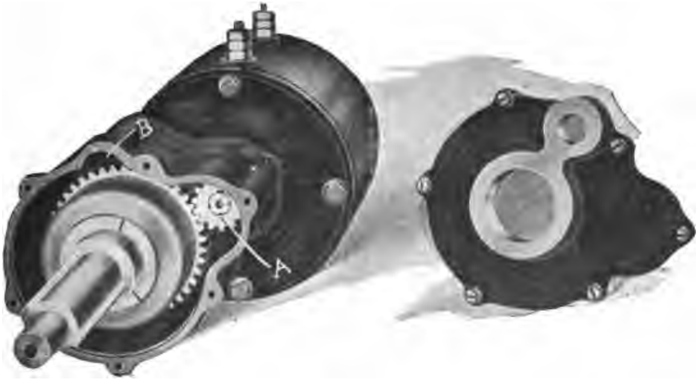


Fig. 223—*End view of* 1914 *Wagner starting motor and reduction gearing*

The starter is connected to the engine by a pinion on the back shaft, which meshes with a gear on the engine flywheel. The pinion is placed on the back shaft and is so arranged that it can

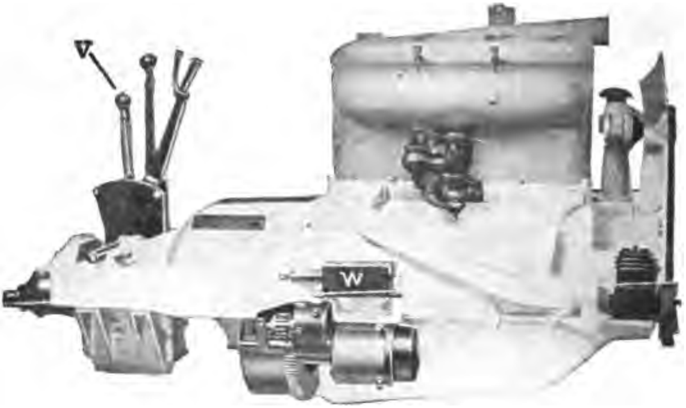


Fig. 224—Method of mounting 1914 Wagner starting motor and starting switch on engine. Switch W is controlled by lever V

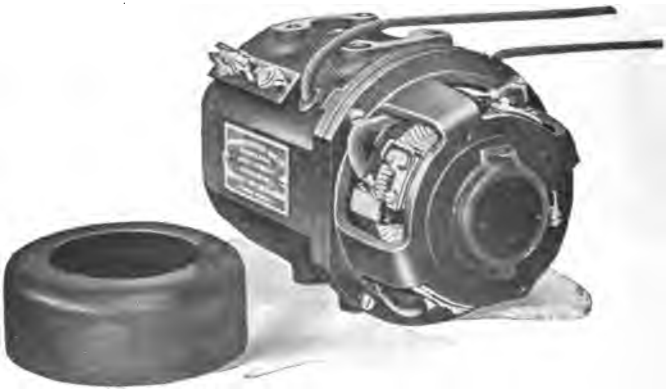


Fig. 225—Wagner 1914 generator with the cover removed

slide on the shaft as it is thrown in and out of gear by the lever V, shown in Fig. 224. The electrical connection between the starting motor and the battery is controlled by a switch, W, Fig. 224, which also is operated by the lever V. The starting operation is accomplished by pushing the lever V forward. When the lever is restored to its original position the pinion is thrown out of mesh and the starting switch is opened.

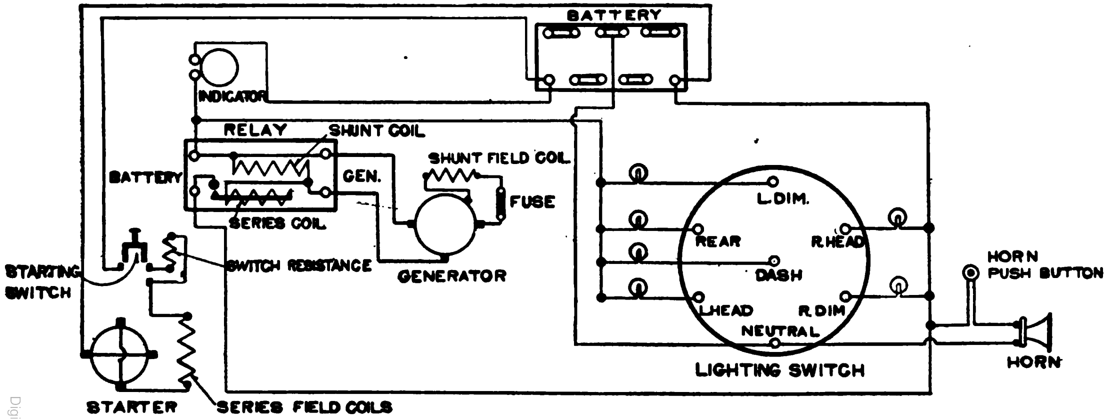


Fig. 226—*Typical wiring diagram of* 1914 *Wagner installation on a motor car*

A view of the generator with the commutator cover removed is shown in Fig. 225. It is a four-pole, shunt-wound machine, which may be driven by the engine through a train of gears, chain or by some other means, which depend upon the particular installation.

The generator output is regulated by the third-brush method. A small cartridge fuse, Fig. 225, is connected in the shunt-field circuit. If from any cause the generator is operated on open circuit, such as with the battery removed from the car or disconnected, the tendency of the field current is to increase to an abnormal value, which will cause the voltage to rise to an abnormal value. The fuse will blow before the field current gets too high and thus prevent the voltage rising to an excessive value, as the generator will not generate if the field circuit is open.

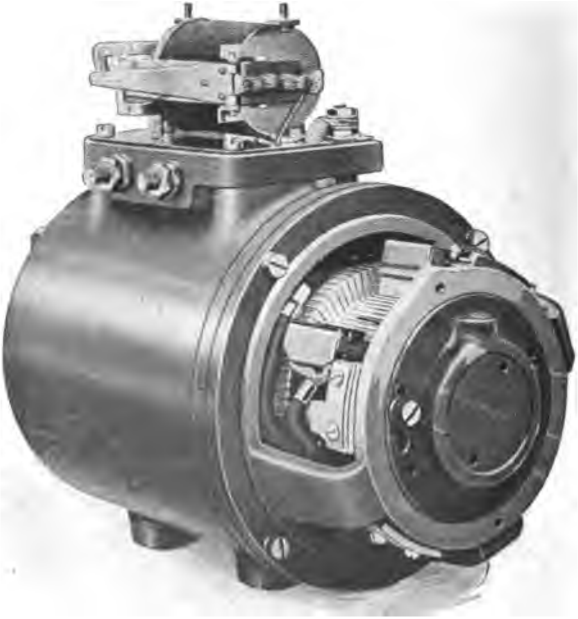


Fig. 227—*Wagner generator with automatic cutout mounted on top, which was used in the* 1914 *systems*

The cutout relay is designed to be located on the dash and is of the customary type, having two windings. One of these windings, called the series windings, carries the current to or from the battery, depending upon whether it is charging or discharging, and the second winding, called the shunt winding, has a current in it which varies directly as the voltage, as this winding is connected across the line.

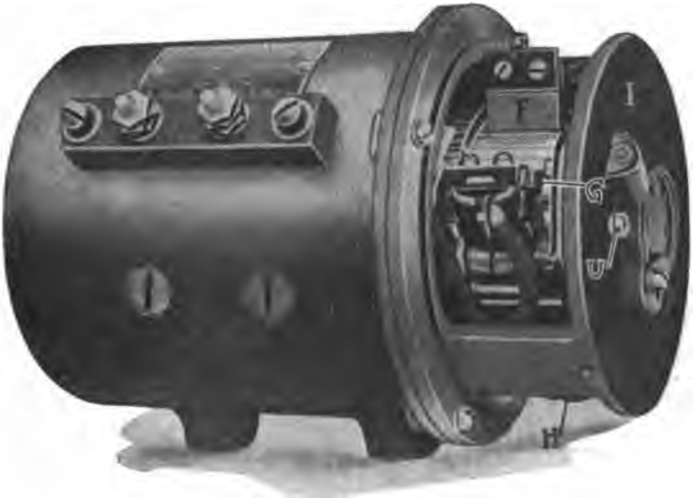


Fig. 228—*Wagner generator used with the* 1915 *systems*

The electrical connections of a system of this kind are shown diagrammatically in Fig. 226. The lights are operated on a three-wire system, and a neutral wire is run from the center of the battery to the lighting switch, as shown in the figure.

1914-1915 Wagner Systems

The construction of the starting motor and back gear for the Wagner 6-volt, two-unit, two-wire system for 1914 and 1915 are practically the same as that in the system described in the previous section. The starting motor is connected to the engine by a chain which operates from a sprocket on the back shaft of the starting motor to a sprocket on the engine shaft. An over-running clutch prevents the engine from driving the starting motor.

The starting switch is of the push type and is mounted on the under side of the toe board within easy reach of the driver.

The generator is a four-pole, shunt-wound machine, and its output is regulated by the third-brush method. A view of the generator and cutout with their covers removed is shown in Fig. 227. In the 1915 systems the cutout was located in the tool box under the driver's seat. The generator used with this system is shown in Fig. 228. The brushes H and I collect the main current from the commutator of the generator. The brushes F and G supply current to the shunt field winding. The position of the brush G may be changed by loosening the screw U and moving the brush in the direction necessary to bring about the desired change in generator output. The adjustment in the position of this brush should be made by an experienced man.

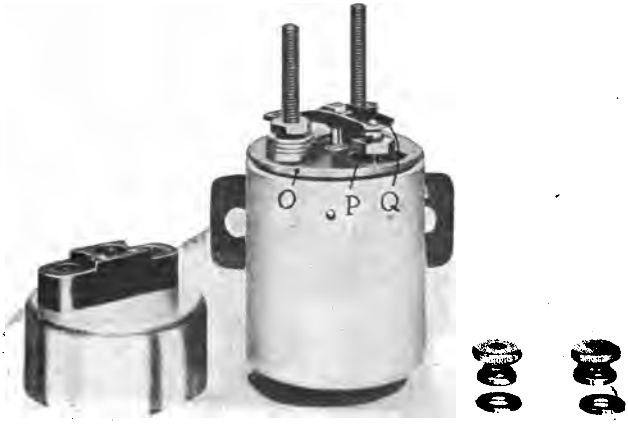


Fig. 229—*Wagner electromagnetic cutout used with the* 1917 *installations*

1916-1917-1918 Wagner Systems

The generator in the Wagner 6-volt, two-unit, single-wire systems for 1916-1917-1918 is a round frame, two-pole, shunt-wound machine. The regulation of the generator output is by the third-brush method. The position of the third brush is adjustable, and the output of the generator may be adjusted by moving the third brush. The generator has only one insulated terminal, as it is used with a single-wire system. The method of driving the generator will depend upon the particular installation and may be by silent chain, train of gears, etc.

The cutout is cylindrical in form and is provided with two insulated terminals. The shell of the cutout forms one terminal of the shunt winding, and it must be well grounded. A view of the cutout with the cover removed is shown in Fig. 229. Its operation is as follows: When the current in the shunt winding has increased to a sufficient value, due to the increase in the voltage of the generator, the disk O is drawn toward the core of the electromagnet and the contacts Q and P close. As soon as these contacts are closed the generator starts to charge the battery, and the magnetizing action of the current in the series winding assists the magnetizing action of the current in the shunt winding. If for any reason the battery starts to discharge, the contacts Q and P are separated and the circuit between the generator and the battery is broken. The contact close at an engine speed of 7 to 10 miles per hour.

In some installations the generator is mounted on end, with the commutator end on top. A generator whose construction is such that it may be mounted on end is shown in Fig. 230.

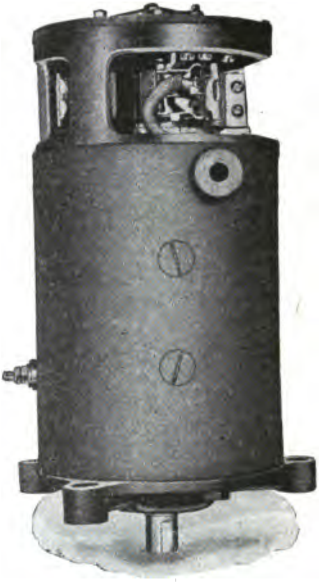


Fig. 230—Wagner generator so constructed that it may operate in a vertical position

The starting motor is a four-pole, series-wound, four-brush, two-terminal machine. A pinion on the motor shaft meshes with a large gear which may form part of the Bendix screw mechanism, or it may be mounted on a shaft carrying a chain sprocket. This sprocket may be connected to a second sprocket on the engine crankshaft by a silent chain and over-running clutch. The starting motor shown in Fig. 231 drives the engine by a silent chain which runs over a sprocket mounted on the shaft D. The Bendix gear may mesh with a gear on the flywheel or it may mesh with a gear mounted on the end of the generator shaft, the generator being connected to the crankshaft of the engine by sprockets and a silent chain.

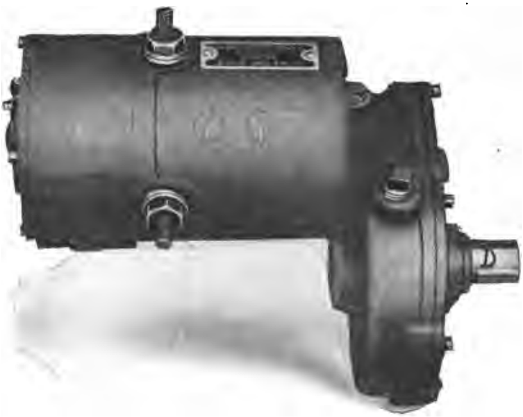


Fig. 231—*One of the latest models of the Wagner starting motor*

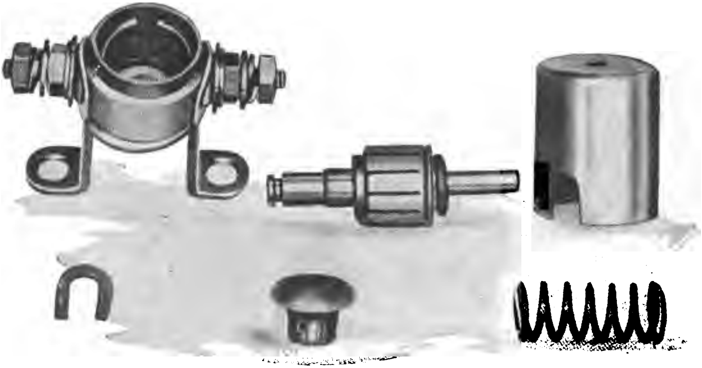


Fig. 232—*Exploded view of Wagner starting switch*

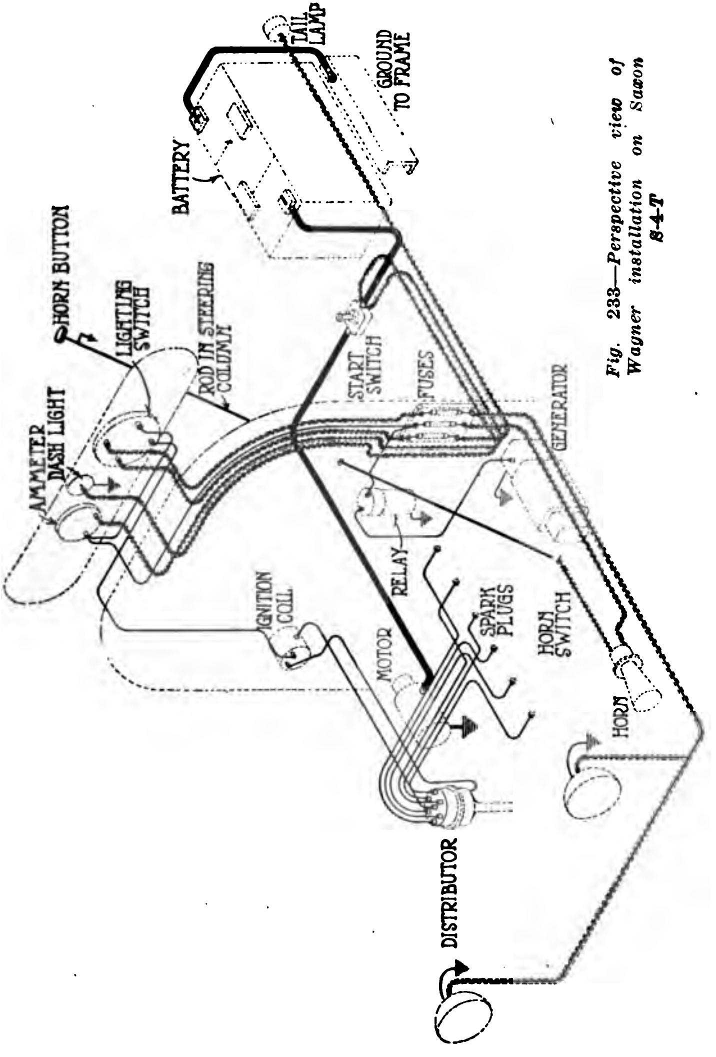


Fig. 233—Perspective view of Wagner installation on Saxon S-4-T

The starting switch is mounted under the floor board in the majority of cases and is of the thrust type. An exploded view of a starting switch is shown in Fig. 232.

Wiring of Saxons

A perspective wiring diagram of the Wagner installation on the Saxon six is shown in Fig. 233. This is a single-unit, 6-volt, single-wire system with the positive side of the system grounded.

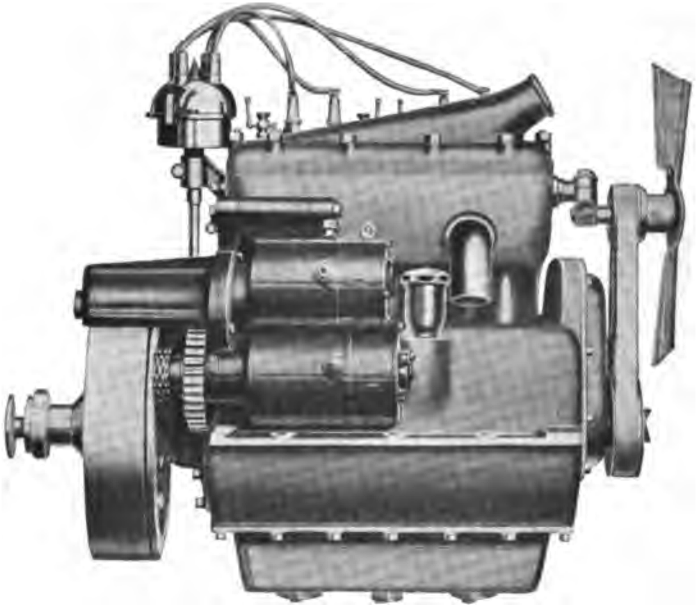


Fig. 234—Wagner installation on Saxon B-5-R

The taillight, headlights and horn are protected by fuses mounted on a fuse block located on the dash of the car. The lamp circuits, except the dashlamp and the ignition, are controlled by a combination ignition and lighting switch.

A Wagner installation on a Saxon model B-5-R is shown in Fig. 234. In this installation the motor is mounted above the generator, and a Bendix pinion on the starting motor shaft engages

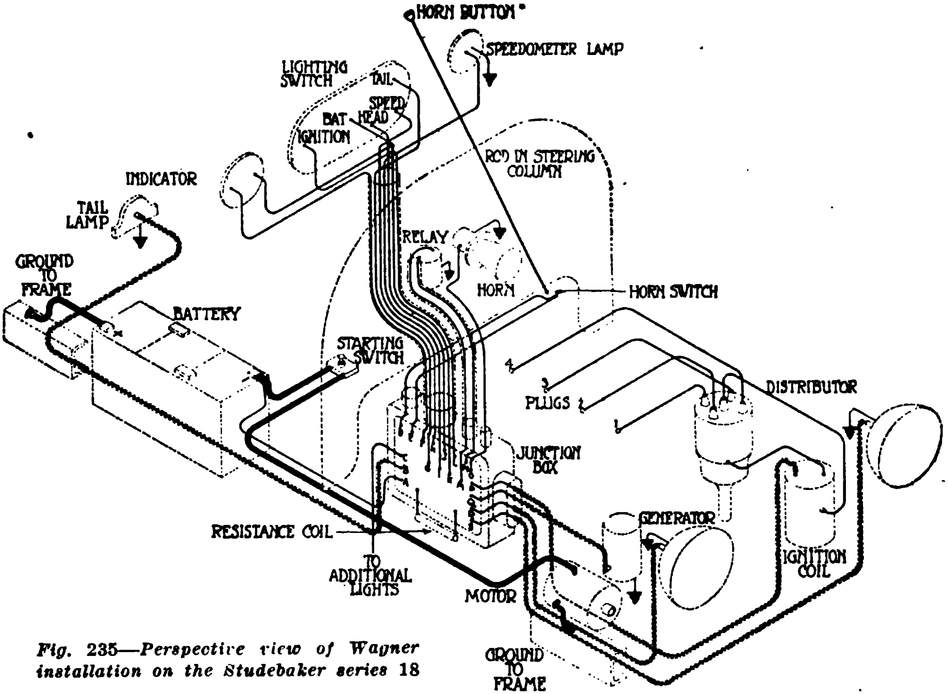


Fig. 235—Perspective view of Wagner installation on the Studebaker series 18

a gear on the generator shaft. The generator is driven by a silent chain. The mounting of the ignition distributor is shown clearly in the figure.

Wiring of Studebaker Series 18

A perspective view of the installation of the Wagner system on the Studebaker Series 18 model is shown in Fig. 235. This is a two-unit, 6-volt, single-wire system with the positive side of the battery grounded. A view of the electrical installation on the engine is shown in Fig. 236.

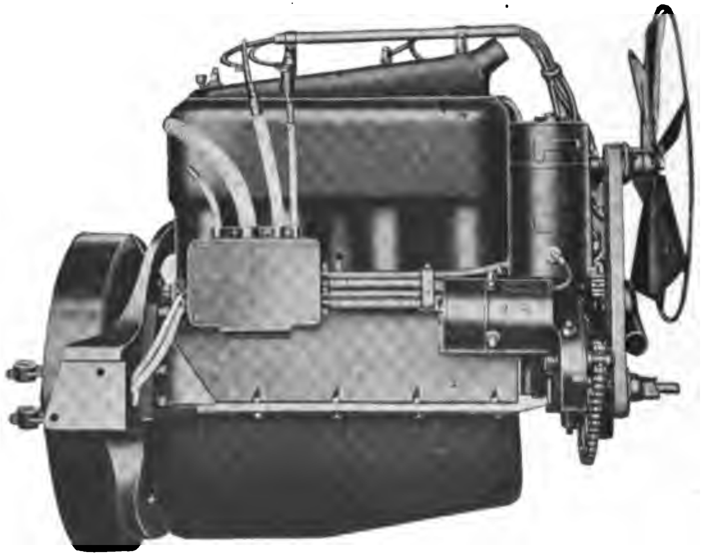


Fig. 236—Wagner installation on Studebaker car, showing generator, starting motor and junction box

From the junction box the wires run to all the various parts of the electrical system. The junction box carries the fuses and the whole thing is inclosed in a housing for protection. The resistance used in dimming the headlights is mounted on the outside of the junction box. The internal connections of the various circuits in the junction box are shown in Fig. 237.

The ignition system, which is manufactured by the Remy Elec-

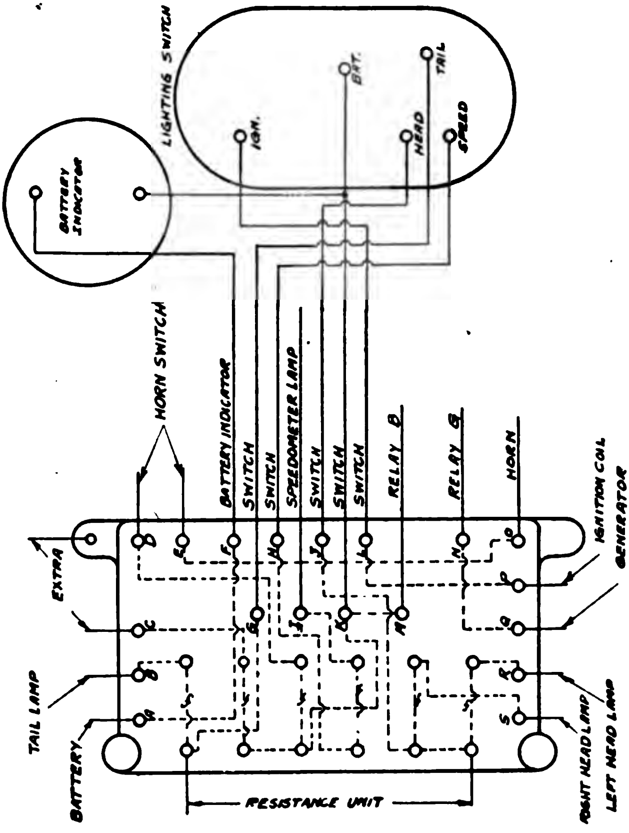


Fig. 237—Internal connections in junction box used on Studebaker

tric Co., consists of the coil, the combined timer and distributor and the spark plugs. The ignition is shown installed in Fig. 238. The current for ignition is drawn from the storage battery when starting and from the generator when running. The combined timer and distributor should be inspected occasionally to see that no oil or dirt has accumulated inside or other foreign matter between the terminals on top of the distributor. Any such accumulation should be cleaned out carefully, as its presence will cause the contact points to wear away rapidly.

If inspection of the contact points shows that the surfaces of contact are flat and have a frosty appearance, this is an indication of perfect condition. If the contact surfaces appear very rough or pitted, they should be smoothed flat. After smoothing off it is necessary to readjust. This work should be handled by an experienced man.

The grease cup which lubricates the distributor shaft should be given a single turn about once every 2,000 miles.

To determine whether the ignition in any cylinder is in good operating condition, remove the wire from the spark plug and hold it by the insulation about ⅛ to ¼ inch from the body of the spark plug. If the spark jumps from the wire to the spark plug body, the ignition up to the spark plug is in good order. To test the plug, remove it from the cylinder and re-attach the wire to it. Then clean the points of the plug and see that the gap between them has been corrected to the proper width, .025 inch. Lay the spark plug on its side on the cylinder and start the motor. If the plug is in good condition, you will see a spark jump the gap

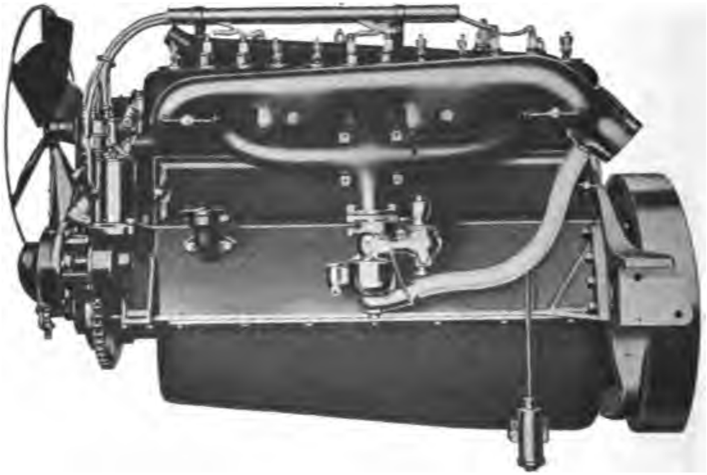


Fig. 238—Remy ignition installed on a Studebaker engine

between the joints. If the spark does not jump the gap the plug may require cleaning. Oil and soot covering the parts adjacent to the points will short-circuit the gap and kill the spark. To clean the spark plug use a tooth brush and gasoline. After the spark plug is cleaned repeat the operation, and if the spark still does not jump the gap a new plug is necessary.

Unless you have completely overhauled the engine, it ordinarily will not be necessary to readjust the timing of the spark. But if it has been necessary, in making repairs, to disturb the relation between the two bevel gears which drive the distributor shaft, it is necessary to retime the engine, which work should only be done by an experienced man.

CHAPTER XXIII

Bijur Electrical Systems

SEVERAL different types of electrical equipment for the motor car have been made by the Bijur Motor Lighting Co. during the last few years, and a brief description of the main character-

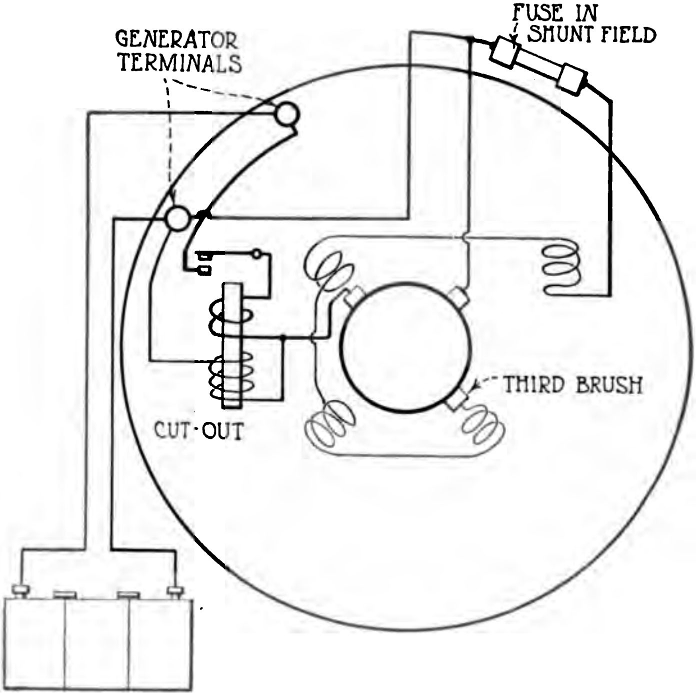


Fig. 239—Internal connections of Bijur third-brush generator

istics of each of these systems and what might be called a typical installation will be given in the following paragraphs.

Third-Brush Regulation

Bijur generators with third-brush regulation have a shunt winding, and the output is regulated by the third-brush method. An electromagnetic cutout with two windings, a series and a shunt, is connected in circuit between the generator and the storage battery and auomatically connects and disconnects the generator and the battery. This cutout is mounted in the commutator end of the dynamo and is accessible for adjustment by removing the brass band from around the generator. The internal connections of the generator are shown in Fig. 239.

Only two wires lead from the generator, as shown in the diagram, and they run to the storage battery through a junction block and fuse block located on the engine side of the dash. The generator is reversible, and connections may be made to the generator without any regard to the polarity of the lines. If the wrong connections are made, the generator automatically will assume the correct polarity to charge the storage battery. The battery and generator always should be connected so the indicator in circuit will show charge when the battery actually is charging and discharge when the battery actually is discharging.

On one end of the generator is an aluminum housing held in place by two screws. This housing protects a glass-inclosed fuse connected in the shunt field circuit as shown in Fig. 239. The generator never should be run with the storage battery disconnected unless this fuse is removed first.

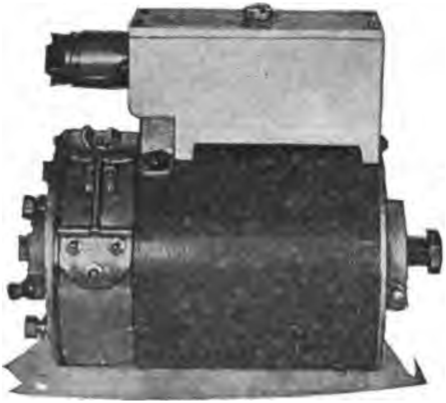


Fig. 240—Bijur generator with regulator mounted in aluminum box on generator

Electromagnetic Regulation

Bijur generators with electromagnetic regulation have a shunt field winding, and the resistance of the field circuit is varied intermittently in value by a special regulator. The winding of this special regulator is connected across the terminals of the generator and the current in the winding varies directly as the voltage of the generator. The action of the regulator is such that it tends automatically to maintain the voltage of the generator constant.

An automatic electromagnetic cutout is mounted in the same housing with the automatic voltage regulator. In some cases the cutout and regulator are mounted inside the generator housing, and in some cases they are mounted in a housing on top of the generator as in Fig. 240. The internal connections of two regulators and cutouts are given in Figs. 241 and 242. The hous-

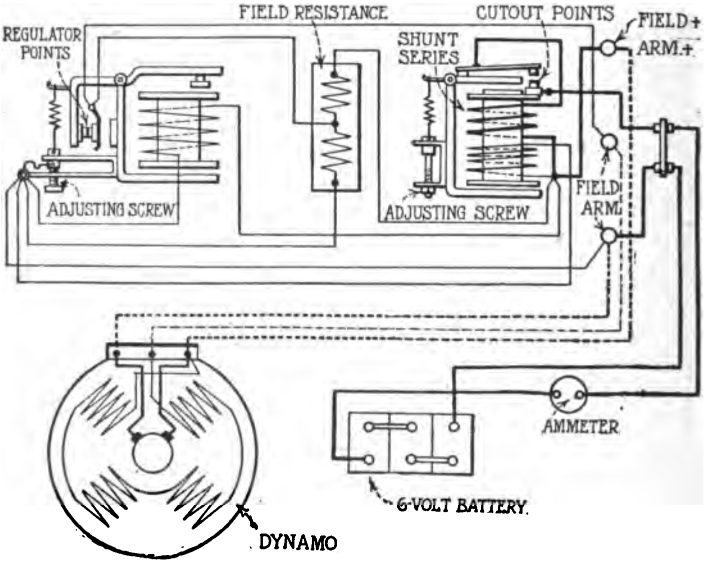


Fig. 241—Internal connections of Bijur combined electromagnetic cutout and regulator mounted on top of the electrical unit

ing containing the cutout and regulator, usually spoken of as the regulator box, is held in place by a special knurled screw. Projecting from the rear of this box, or from the end of the generator housing when regulator and cutout are mounted inside the generator and fitting into a receptacle, is a disconnecting and reversing plug.

The two wires which connect the generator and battery are soldered into the terminals of this plug. This plug is made in either of two ways, with two flat parallel faces or round and knurled on the portion extending into the shell which it fits. The plug may be turned a quarter revolution in either direction from the position it has when it enters the receptacle, and when rotated to either of these positions and allowed to spring out-

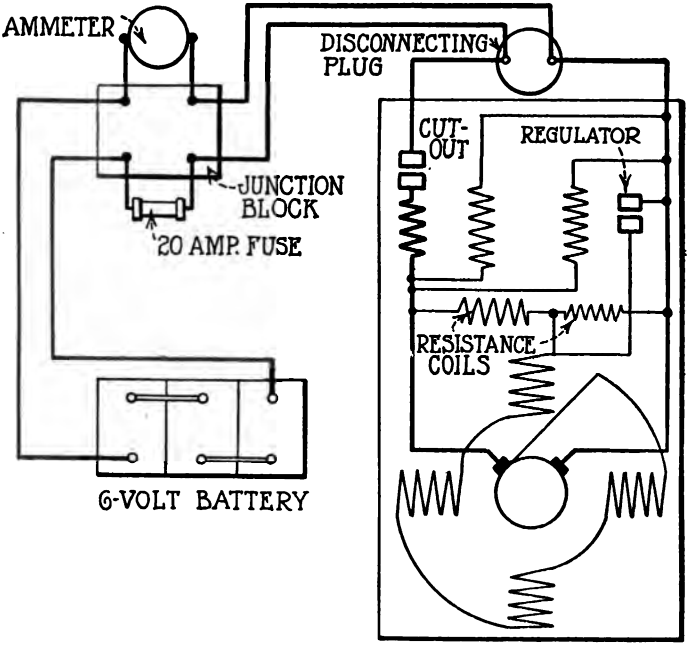


Fig. 242—Internal connections of Bijur combined electromagnetic cutout and regulator mounted inside the housing of the generator

ward under the influence of a compressed spring it will be locked in place. Pressing it in and turning to the other extreme position reverses the connections and causes the polarity of the generator to change. The manufacturer recommends that the position of the plug be changed about every 500 miles. It is not advisable to change the plug unless the storage battery is practically fully charged.

Combined Starting Motor and Generator

The internal connections of the combined starting motor and generator unit are shown in Fig. 243. It is a compound-wound four-pole machine with a round frame, and the output of the unit when operating as a generator is regulated by a combination of the third-brush and differential or bucking series field types of regulation. No automatic cutout is used with this machine, but it is connected permanently to the battery while the engine is running.

Starting Motors and Drives

The separate starting motors are all round-frame, four-pole, series-wound. Power is transmitted to the engine by a Bendix drive or a small pinion is made to slide on the square shaft of the starting motor by the operation of the starting pedal or handle which also closes the starting switch. The first position on the starting switch connects a resistance in series with the starting motor and battery, and the motor operates at a slow speed, which assists in the meshing of the driving gears. The resistance is cut out of circuit after the gears are in mesh by a farther movement of the starting switch. This small pinion is disengaged as soon as the starting pedal or handle is released and the starting switch is opened.

In the combined generator and starting motor units, the armature is connected to the engine crankshaft by a chain.

Bijur on Apperson 4-40 and 6-45

The Bijur installation on the Apperson 4-40 and 6-45 is of the three-unit, 6-volt, two-wire type, Fig. 244. The output of the generator is regulated by the third-brush method, and the generator automatically is connected to and disconnected from the battery by an electromagnetic cutout mounted inside the generator housing. The generator is reversible, and only two wires connect to the generator.

The starting motor is provided with a square shaft, and a pinion is mounted on this shaft. The pinion can be moved horizontally along the shaft. It meshes directly with the teeth in the edge of the flywheel, and no intermediate gears of any kind are used. The starting handle on the cowl connects through linkage to a trunnion which moves the pinion on the square shaft of the motor. The starting lever also operates the start-

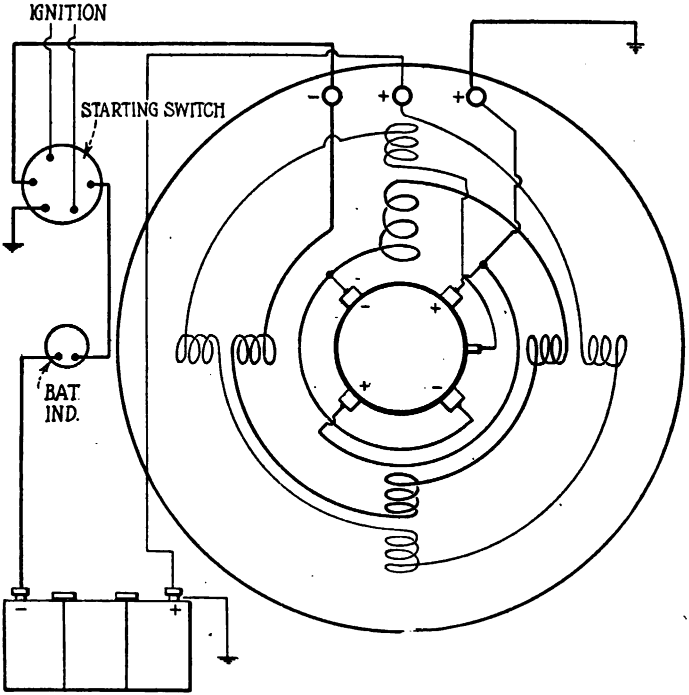


Fig. 243—Internal connections of Bijur combined generator and motor unit with generator regulation—a combination of third-brush and bucking methods

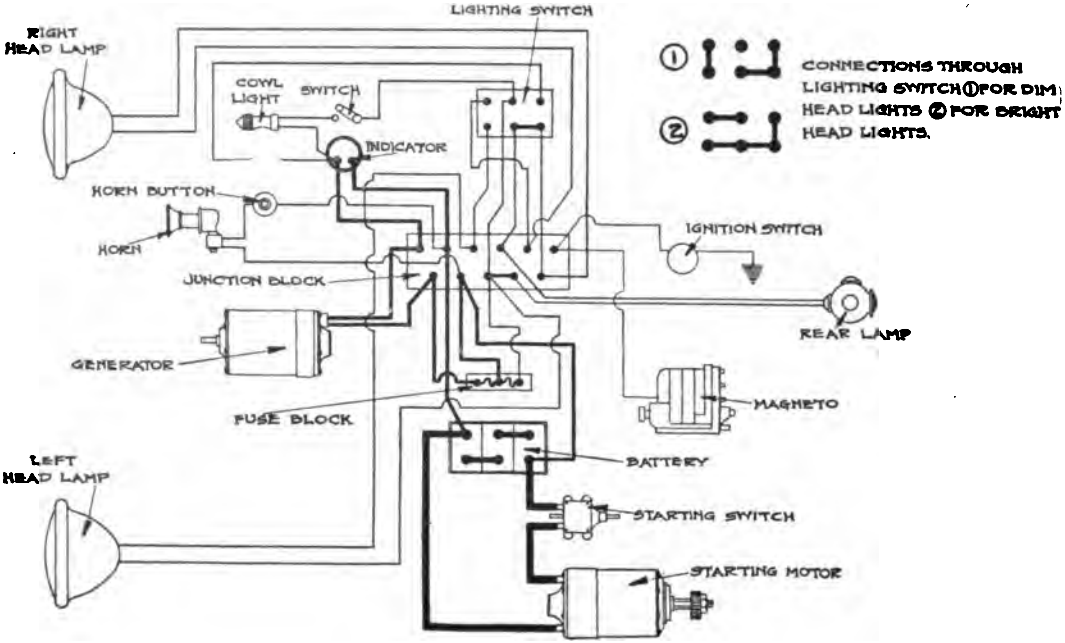


Fig. 244—Wiring diagram of Bijur installation on the Apperson 4-40 and 6-45

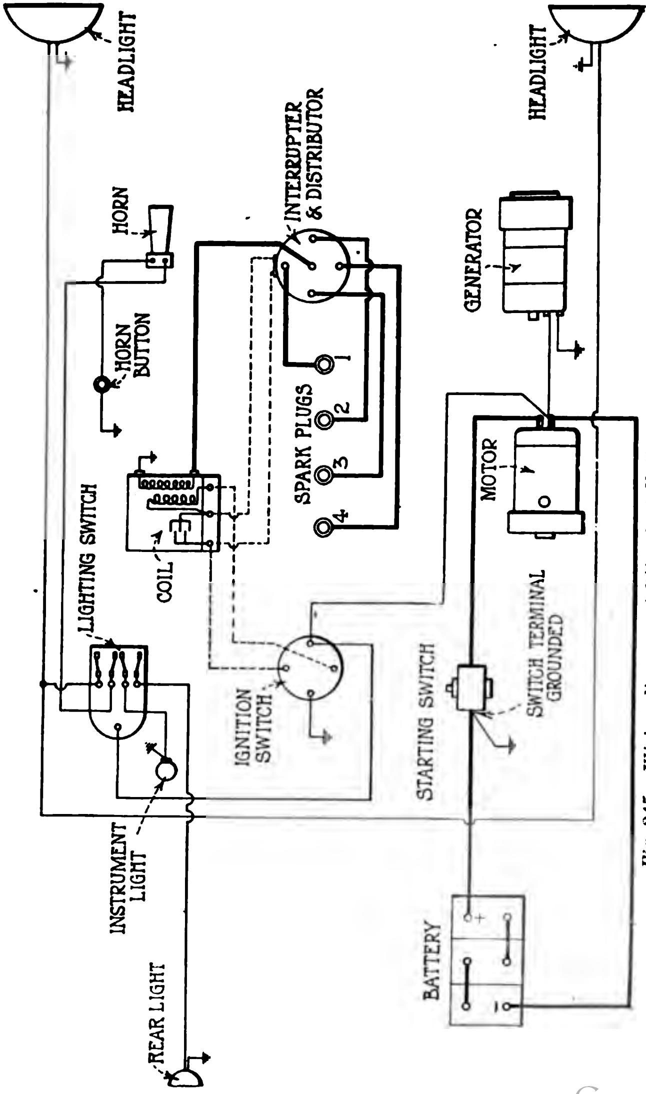


Fig. 245—Wiring diagram of Bijur installation on the Hupmobile N

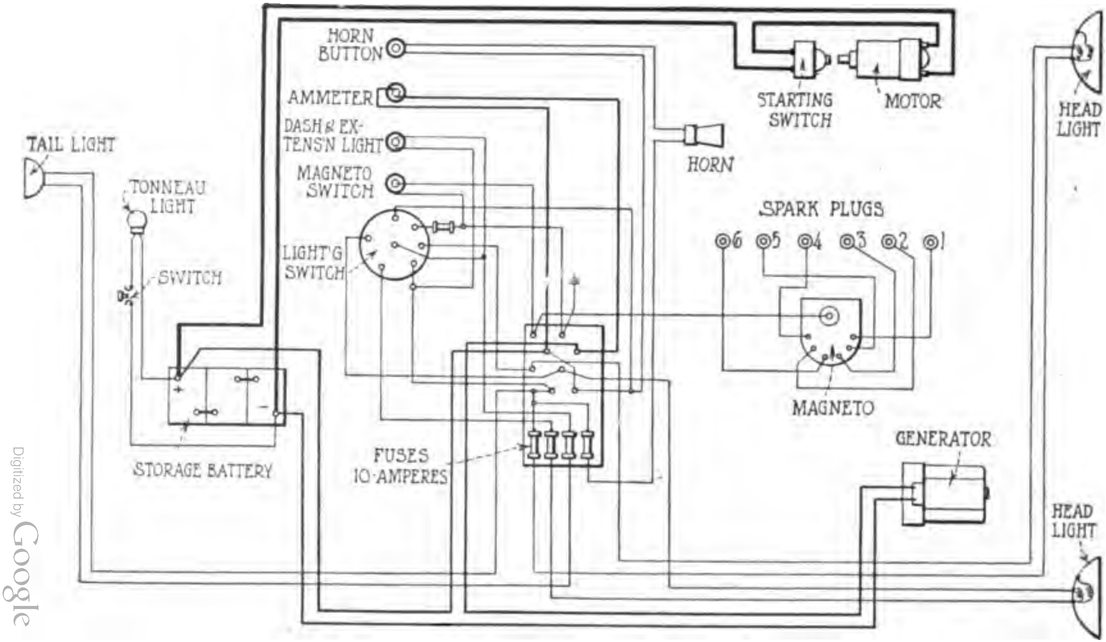


Fig. 246—Wiring diagram of Bijur installation on the Jeffery Chesterfield six

ing switch. The pinion normally is held out of mesh with the gear on the flywheel by a spring which also holds the starting switch in the open position.

The first movement of the starting handle closes a set of contacts on the starting switch, which connects the motor to the storage battery with a resistance coil in series. This resistance coil is inside the starting switch. The starting motor turns over quite slowly when the resistance coil is in circuit and thus enables the pinion on the motor shaft readily to be meshed with the teeth on the flywheel. Farther movement of the starting handle connects the starting motor direct to the storage battery and the motor then will spin the engine.

Ignition is taken care of by a magneto.

A battery charge indicator is located on the cowl board. This indicator stands at ''Floating'' when the battery is neither charging nor discharging. When the charging current exceeds approximately 2 amperes the indicator swings over to ''charge,'' and when the discharge current exceeds approximately two amperes the indicator swings over to ''discharge.''

A two-gang switch on the cowl board controls the two headlamps and the taillamp. The lamp on the cowl board is controlled by a separate switch, or key, at the lamp itself. When the left lighting switch is pulled out the headlamps burn dim, and when both the switches are pulled out the headlights burn bright. The taillight always is lighted regardless of whether the headlights are bright or dim.

A magneto is provided to take care of the ignition, and its operation is controlled by an ignition switch on the dash.

Bijur on 1916 Hupmobile

A wiring diagram of the Bijur installation on the 1916 Hupmobile is given in Fig. 245. It is a three-unit, 6-volt, single-wire system with the negative terminal grounded. The output of the generator is regulated by the third-brush method, and the electromagnetic cutout is located inside the generator housing. The starting motor is a four-pole series-wound motor, connected directly to the engine by a pinion which slides on the square shaft of the motor and into gear with the gear on the face of the flywheel. This pinion is shifted by a yoke, which in turn is oper-

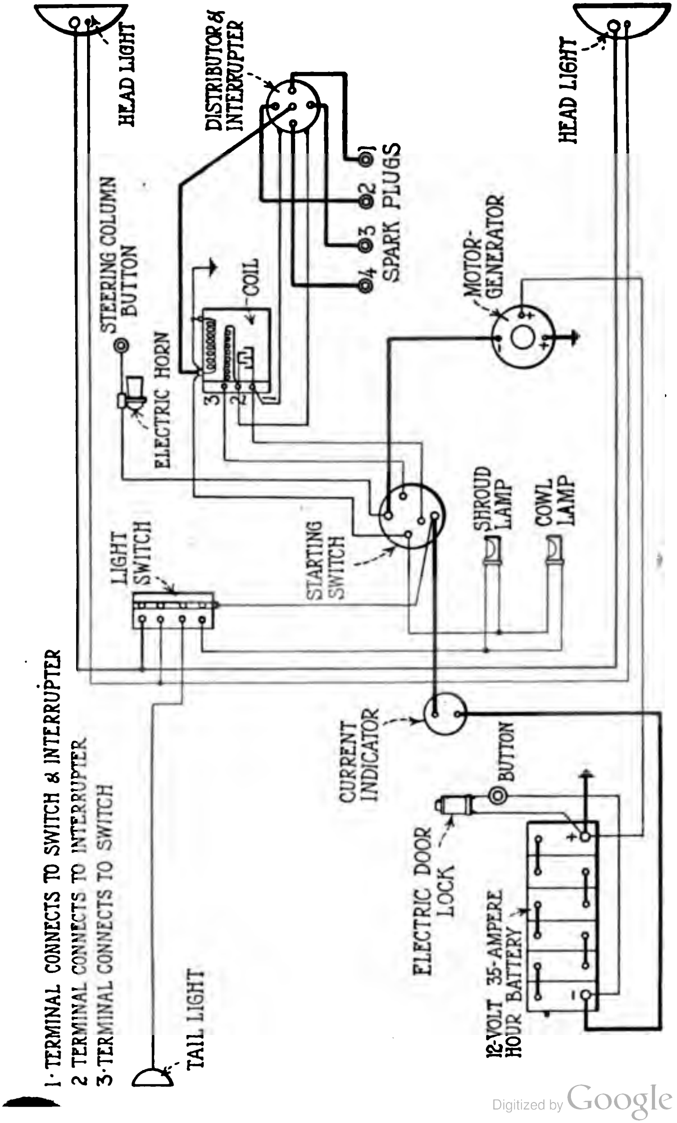


Fig. 247—Wiring diagram of Bijur installation on the first 1100 Scripps-Booth cars

ated by the starting pedal, which also acts to close the starting switch.

The lights are controlled by a four-position lighting switch mounted on the cowl board. Four fuses and the resistance for dimming the headlamps are mounted on the forward side of this switch.

An ignition switch on the cowl board controls the ignition, which derives its current from the storage battery or generator. The wiring diagram of the ignition system is shown in Fig. 245.

Bijur on Jeffery Six

The Bijur system on the Jeffery Chesterfield six is a three-unit, two-wire—except for the headlights—6-volt installation and a complete wiring diagram is given in Fig. 246. The output of the generator is regulated by a constant-voltage regulator, and the current delivered by the generator when it is connected to the storage battery will depend on the condition of charge of the battery. The lower the charge in the battery, the lower its voltage and, hence, the greater the difference between the voltage of the generator and the voltage of the battery, which results in a larger current being produced than when the battery is nearer full charge and its voltage near equal in value to the voltage of the generator. The automatic voltage regulator and electromagnetic cutout are housed in an aluminum box on top of the generator. A special reversing plug is provided, by which the generator may be disconnected or the connections to the generator reversed.

Depressing the starting pedal connects the starting motor to the engine by causing a pinion on the square motor shaft to mesh with a gear on the flywheel of the engine and also closes the starting motor switch.

The out-of-focus lamps are wired to use the frame of the car as one side of the circuit. The dashlight is on the taillight circuit and so arranged that these two lamps are always in operation when any combination of headlights is in operation.

The body and chassis wiring are separate but connected through terminal posts and fuse block located on the engine side of the dash, which permits bodies being changed without the necessity of rewiring.

All the lamp circuits are provided with separate fuses. A

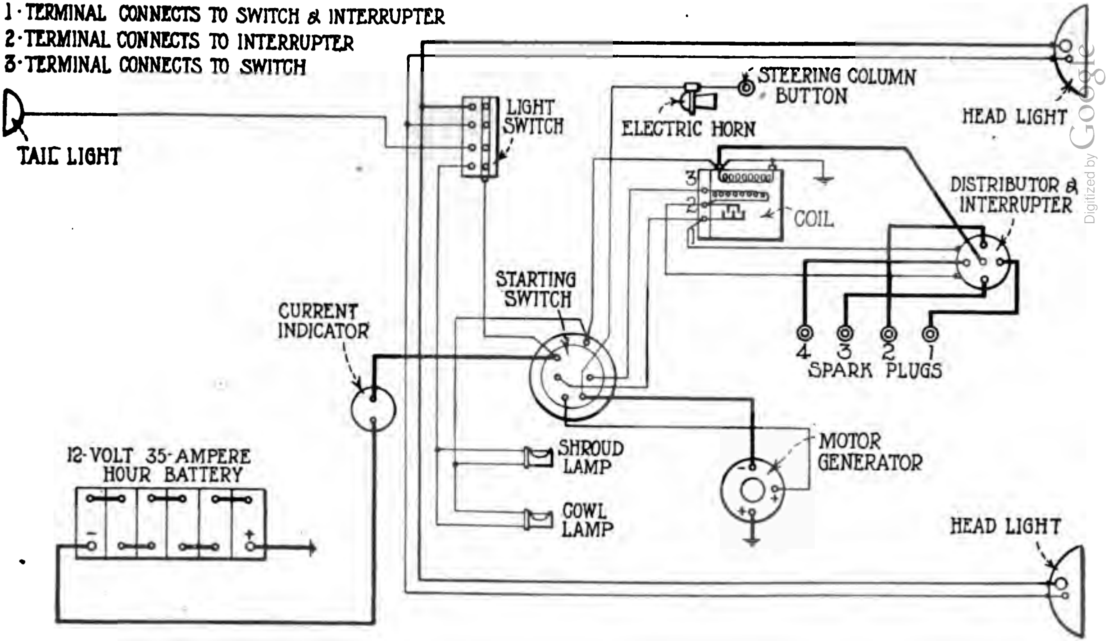


Fig. 248—Wiring diagram of Bijur installation on the Scripps-Booth, beginning with the 1101*st car*

fuse is located in the ground circuit between the magneto tap and the lighting switch, and this fuse will blow if an accidental ground is made on either side of the system. The blowing of this fuse when the lighting switch is in the "off" position, shows that the accidental ground causing this fuse to blow is on the positive side of the system. The blowing of this fuse when the lighting switch is in the "all bright" position or the "out-of-focus bright" position, shows that the accidental ground causing the fuse to blow is on the negative side of the system.

The ignition is taken care of by a magneto controlled by a magneto switch.

Bijur on the Scripps-Booth

The Bijur installation on the Scripps-Booth light cars is a single-unit, single-wire, 12-volt system with the positive side of the battery grounded. A complete wiring diagram of the system, as used on the first 1,100 cars, is shown in Fig. 247. The electrical unit is chain-driven from the crankshaft of the engine and is, therefore, in operation whenever the engine is running. The output of the electrical unit when operating as a generator is regulated by a combination of the third-brush and reversed-series field methods.

A switch on the dash controls the ignition and starting circuits. When this switch is in the "off" position the ignition circuit is open and the electrical unit is disconnected from the storage battery. When this switch is thrown to the "on" position the ignition circuit is closed and the electrical unit is connected to the storage battery. The electrical unit will draw current from the storage battery and act as a motor until the engine starts to run under its own power and drive the electrical unit, which will change to a generator when the voltage generated in its armature is greater than the voltage of the storage battery.

Beginning with car 1,101 a three-position switch is used instead of a two-position switch. A wiring diagram of this system is shown in Fig. 248. With the switch in the "off" position the ignition circuit is opened, the electrical unit is disconnected from the battery and the field circuit of the electrical unit is open. When the switch is in the "on" position all these circuits are closed, and this corresponds to the normal operating position. When the switch is in a third-position between the "on" and

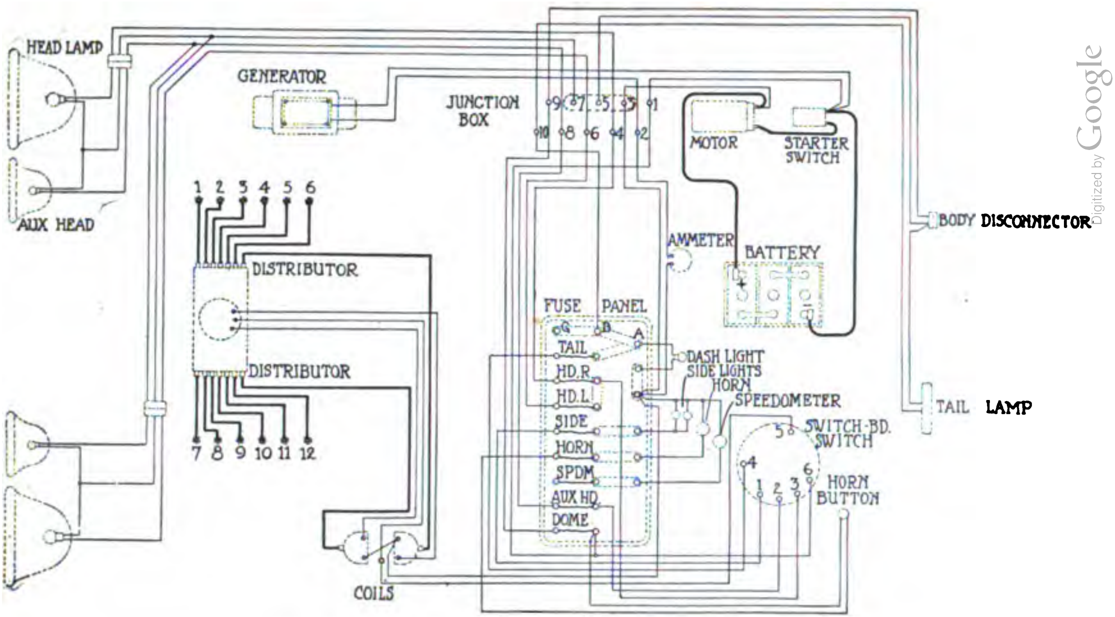


Fig. 249—Wiring diagram of Bijur installation on 1917 Packard, with Delco ignition

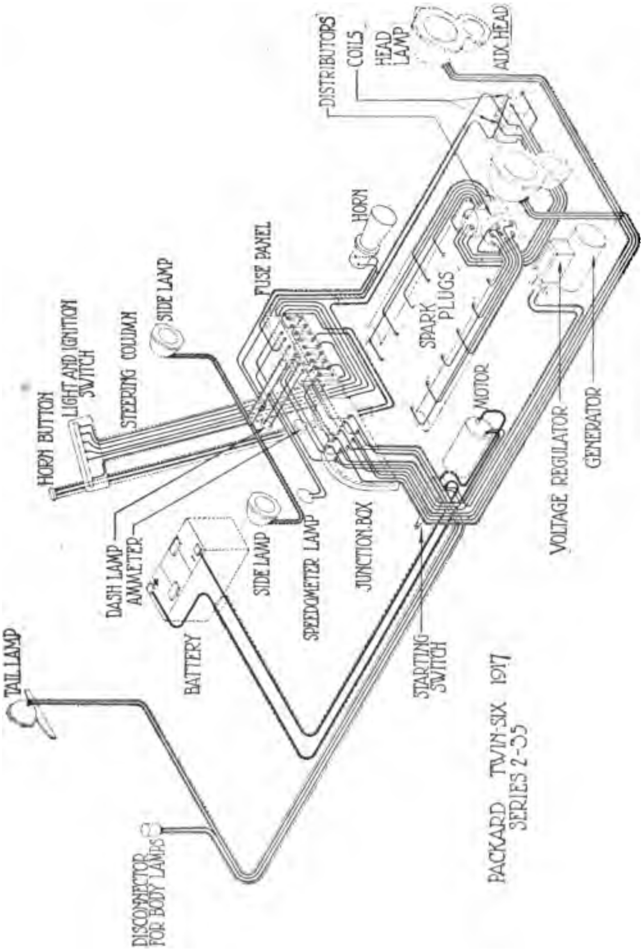


Fig. 250—Perspective view of Bijur installation on 1917 Packard, with Delco ignition

"off" positions and marked "idle" the ignition circuit is closed and the electrical unit is disconnected from the battery and its field circuit is open. With the switch in the "idle" position the storage battery neither charges nor discharges. The switch should

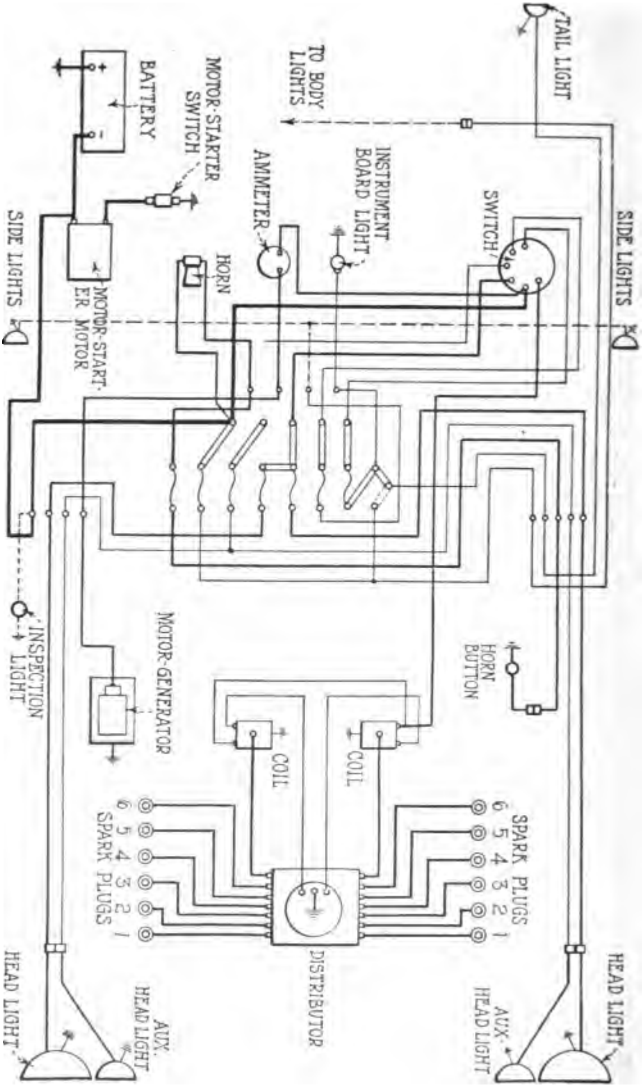


Fig. 251—Wiring diagram of Bijur installation on 1918 Packard Twin-Six

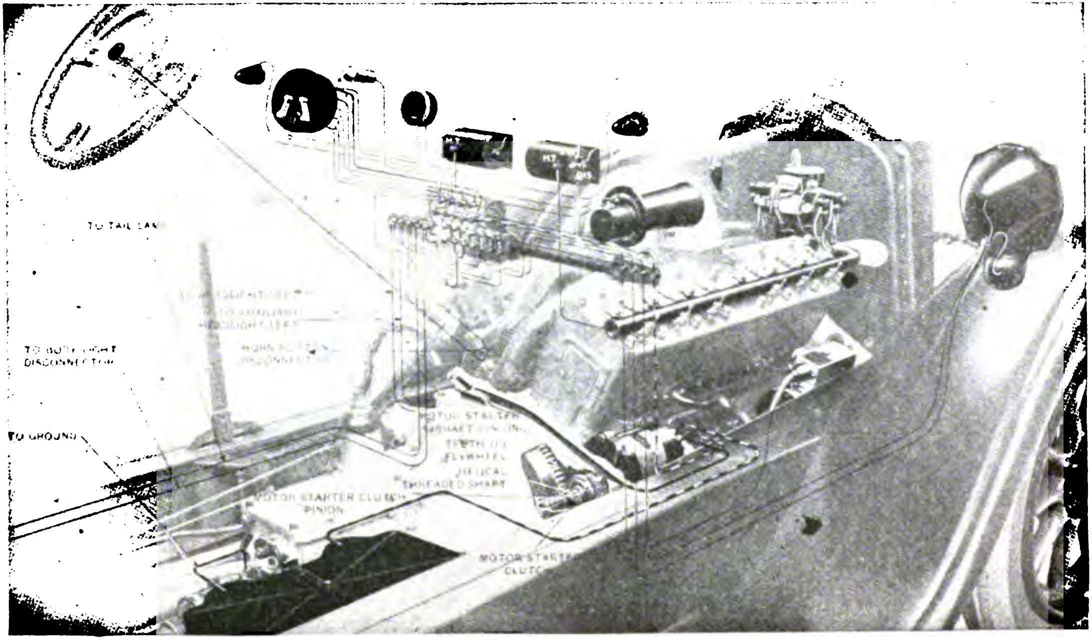

TO TAIL LAM
TO AUXILIARY HEADLIGHT LEFT
HORN BUTTON DISCONNECTOR
TO BODY LIGHT DISCONNECTOR
TO GROUND
MOTOR STARTER SHAFT PINION
TEETH OF FLYWHEEL
HELICAL THREADED SHAFT
MOTOR STARTER CLUTCH PINION
MOTOR STARTER CLUTC

Fig. 252—*Perspective view of Bijur installation on 1918 Packard Twin-Six*

be turned to the "idle" position when the car is standing with the engine running slowly, or when driving very slowly as in congested city traffic. A current indicator on the dash shows whether the battery is "floating," "charging" or "discharging." A four-gang lighting switch located on the dash controls all the lighting circuits.

A battery ignition system is used. The internal connections are plainly shown in Figs. 247 and 248.

Bijur on 1917 Packard Twin-Six

A wiring diagram of the various electrical connections of the Bijur system on the Packard 1917 twin-six is given in Fig. 249, and a perspective view of the complete electrical installation is given in Fig. 250. This is a three-unit, two-wire, 6-volt system. The output of the generator is regulated by a constant-voltage regulator. This regulator and the automatic electromagnetic cutout are inclosed in a box mounted on top of the generator. A junction box is provided on the front of the dash, where all the wires leading to the different lights are connected. Fuses are provided in all the light circuits and also the horn circuit. They are mounted in a panel on the engine side of the dash. The lighting and ignition switch is of special construction and is mounted on the steering column.

The ignition system, which is made by Delco, is of the battery type, and separate high-tension distributors are provided for each cylinder block. A twin interrupter, on top of the distributor unit, completes the low-tension circuit when the interrupter points are in contact. A separate ignition coil is used for each of the interrupters.

Bijur on 1918 Packard Twin-Six

A wiring diagram of the Bijur electrical installation on the 1918 Packard Twin-Six is given in Fig. 251, and a perspective view of the complete installation is given in Fig. 252. This system is a two-unit, single-wire, 6-volt installation. The general layout of the system is the same as that used on the 1917 cars, except for the construction of the ignition and lighting switch. It is mounted on the dash instead of on the steering column.

CHAPTER XXIV

Remy Electrical Systems

REMY installations may be made up of separate units for lighting, starting and ignition or these various units may be combined in different ways, all depending upon the particular installation. All the different systems employing a separate generator and motor are of the 6-volt type and may be either single or two-wire. All the motors are four-pole series-wound. The frames of the machines are rectangular or round, depending upon the model.

Fig. 253—*Remy ignition generator with third-brush regulation*

A double-deck system manufactured by the Remy Electric Co. consists of a separate generator driven by a shaft extending from the timing gear case and a separate motor mounted directly above it. The generator element is a two-pole machine, and the motor element is a four-pole series wound motor. The motor is connected to the engine crankshaft by two pairs of spur reduction gears. An overrunning clutch is mounted in the large gear on the main shaft, and this clutch runs free when the engine is running under its own power.

A combined generator and motor unit having a single armature was used on the 1913 Premier motor car. This unit is of the 12-volt type, and in some cases an interrupter and distributer may be added, thus combining the starting, lighting and ignition functions all in one machine. The armature of this machine was connected directly to the engine crankshaft without any overrunning clutch or similar device, as the armature rotates all the time the engine is in operation.

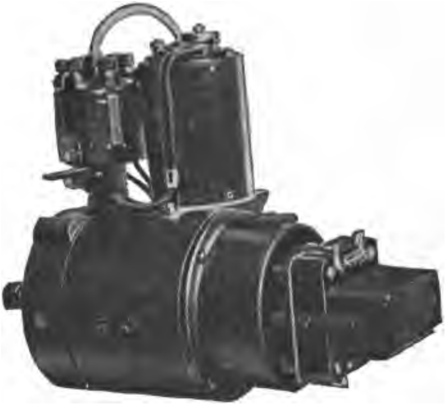


Fig. 254—Remy ignition generator with electromagnetic regulation

A Remy generator with a magneto type of breaker box mounted on one end an a distributer directly above it is shown in Fig. 253. This generator is a 6-volt two-pole shunt-wound machine, and its output is regulated by the third-brush method. Another type of Remy generator is shown in Fig. 254.

The most recent type of Remy generator is a 6-volt, two-pole machine whose output is regulated by the third-brush method in combination with a special thermostatic control, which will be described in detail in one of the following sections. Two types of Remy starting motors are shown in Figs. 255 and 256.

Regulating Output of Generators

Four different methods are employed by the Remy company in regulating the output of their generators, and these methods are:

Third-brush regulation.
Electromagnetic regulation.
Reversed series field regulation.
Combination of third-brush and thermostatic regulation.

The third-brush method of regulating the output of the generators is used on many different models of Remy generators, such as the rectangular generators with or without ignition heads and the double deck rectangular frame generator and motor.

Fig. 255—*Remy starting motor model*

Fig. 256—*Remy starting motor model*

The electromagnetic regulation consists of an electromagnet, usually carried in the same housing as the cutout. This electromagnet operates so as to intermittently insert a resistance in the field circuit of the generator as the current output of the generator increases. Several different types of regulators have been in use, but they all operate on the same principle.

One type of regulator has the cutout and regulator electromagnets mounted in a horizontal position, while in another type they are mounted in a vertical position. The operation and adjustment of both types is practically the same. Some of the more recent regulators are so constructed that the current taken by the lamps does not pass through the entire regulator winding, so that when the lamps are turned on the strength of the electromagnet of the regulator in relation to the output is decreased and the generator output thus is increased to take care of the additional lamp load.

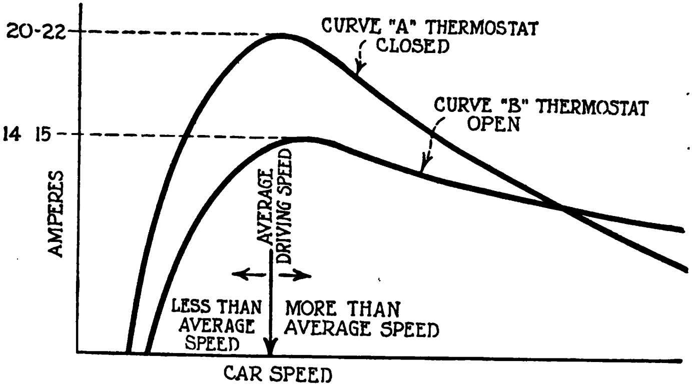


Fig. 257—Curves showing relation between car speed and generator current with thermostat contact points closed and open on Remy generator

The generator used on the 1913 Premier motor car was a two-pole compound wound machine with the series field winding connected in such a way that its magnetizing action was opposed to the magnetizing action of the shunt field winding. The connections of the lamp circuits is such that when current is being supplied to the lamps it passes through only a part of the series winding, which causes the generator to have a greater output than it would have if all the current were going to the storage battery.

Combined Third-Brush and Thermostatic Regulation

The main regulation of the generator is taken care of by the third-brush method. A specially constructed thermostat is mounted inside the generator housing. A resistance coil is connected across the contacts of this thermostat, and the contacts normally are closed. The terminals of the thermostat are connected directly in series with the shunt field winding of the generator, and when the contacts of the thermostat are open the resistance is connected in series with the field winding. The adjustment of the thermostat contacts is such that when the temperature of the generator has reached an approximate predetermined value the resistance is introduced in the field circuit and the generator output lowered. Two curves showing the relation between output of the generator in amperes and speed, with and without the resistance in circuit, are given in Fig. 257. The chief advantages of this device are that it gives a larger generator output in cold weather when the efficiency of the battery is lower than in warm weather and also a larger output when the car is being driven intermittently and the demands on the battery are greater, due to the frequent use of the starting motor.

Remy Cutouts

The cutouts are of the electromagnetic type, with a shunt and series winding. The construction of the generators is such that cutout closes at a rather low speed in miles per hour. The combined cutout and regulator may be mounted on the generator or as a separate unit on the dash or some better location.

Starting Motors, Drives and Switches

The separate starting motors are four-pole series-wound machines, and may be connected to the engine crankshaft by a reduction gearing and overruning clutch, by a special chain drive and ratchet, as used on the Reo car or by the Bendix drive. In the case of the combined generator and motor unit no overrunning clutch of any kind is used, but there is a definite connection between the armature of the electric unit and the crankshaft of the engine.

Two general types of starting switches are used. One of these is the tapered plunger type, in which the two contacts are connected together by depressing a plunger or pulling or pushing a rod. The other type uses copper bands, which slide on cylinders of insulating material. Contact bands are mounted on the cylinders in such a position that the sliding rings couple the circuit between the contact bands when fully depressed.

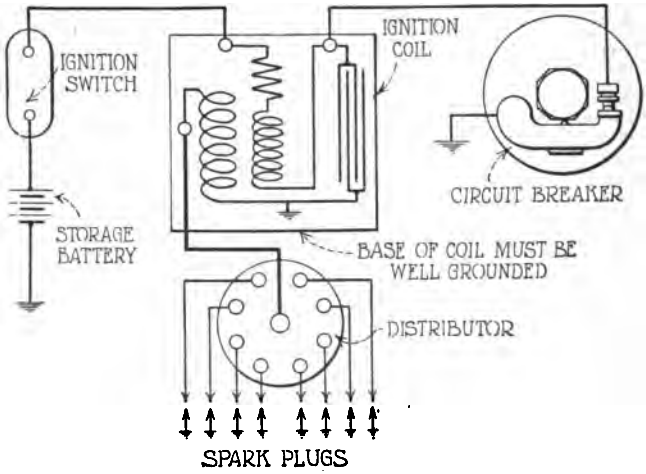


Fig. 258—Wiring diagram of Remy grounded ignition system

Remy Ignition

Two types of battery ignition systems are made by the Remy company, the grounded and the insulated. In the grounded ignition system, such as on the Chalmers model 35, the primary winding of the ignition coil is grounded, as is also the circuit breaker arm. In the insulated ignition system, such as that used on the Reo, Velie and McLaughlin motor cars, the circuit .breaker is connected directly across the primary winding of the ignition coil, no ground being used. In the grounded ignition system the coil base is used for grounding the primary winding, and in both systems the base is used for grounding one end of the secondary winding. Therefore, it is necessary that the base of coil should be clean and should make good contact.

A condenser connected in shunt with the breaker contacts on all systems, the object being to reduce arcing at contacts and raise the efficiency of the coil.

A resistance is used in series with the primary winding of the ignition coil on many of the equipments, such as on the Velie, Chalmers, etc. This resistance is mounted on top of the coil tube, its action being to allow a strong current to flow for starting when the engine is cold. Then as the resistance heats up and increases, due to heat, the current is reduced. This resistance, though operating very successfully under normal conditions, is likely to be burned out if the ignition switch is forgotten and left on when the engine is not running. It therefore is installed on top of the coil, where it is readily accessible for replacement. The wiring diagram of a grounded ignition system is shown in Fig. 258, and an insulated system is shown in Fig. 259.

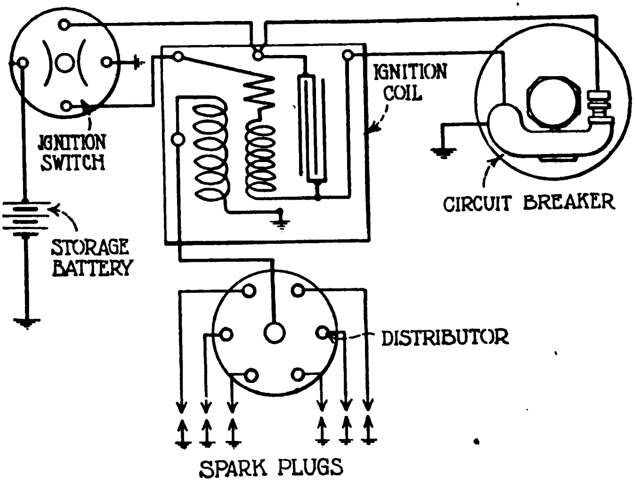


Fig. 259—*Wiring diagram of Remy insulated ignition system*

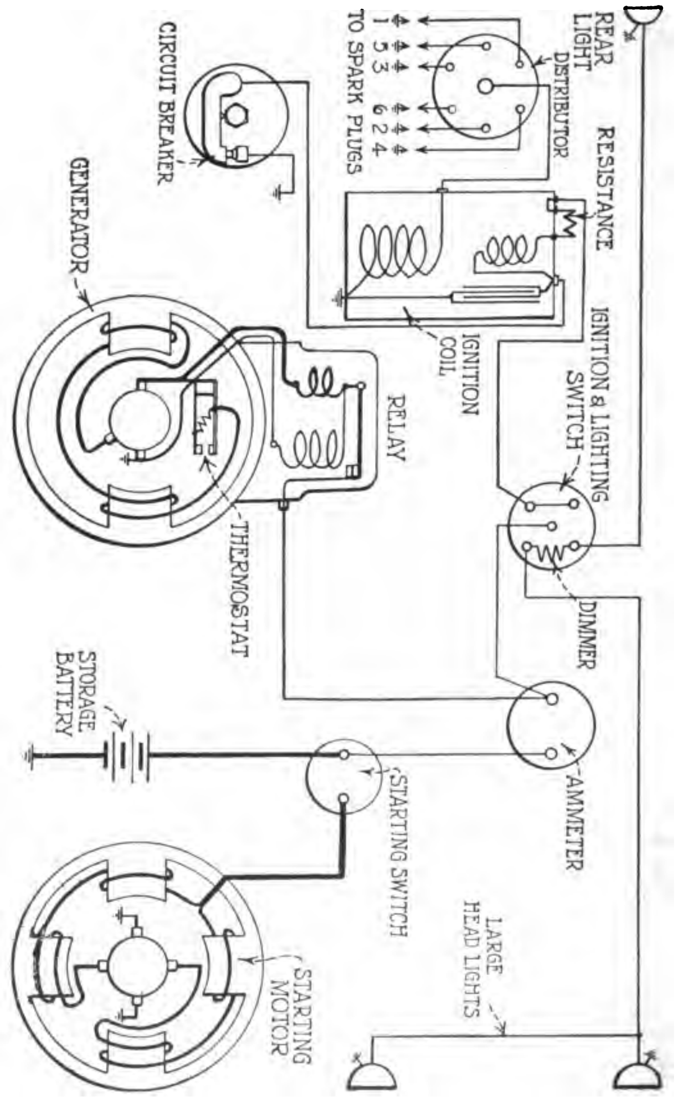


Fig. 260—Remy electrical installation on the Oakland 34-B

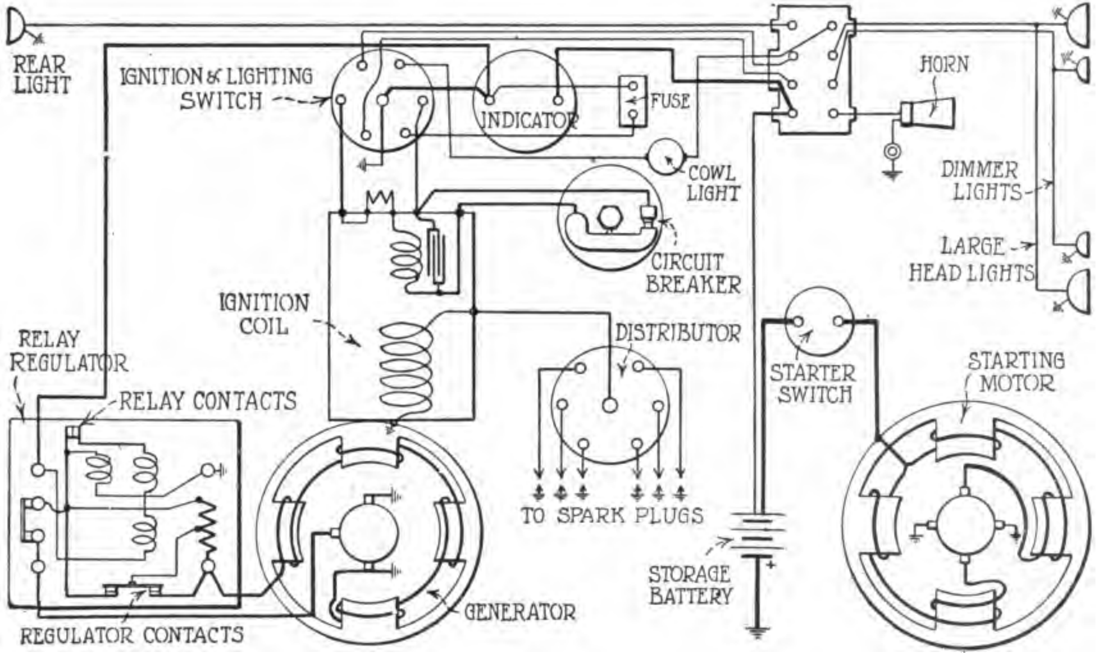


Fig. 261—*Remy electrical installation on the Velie* 28

Remy makes several different types of magneto ignition systems in addition to the battery ignition systems.

Methods of Dimming Head Lights

Three methods of dimming the headlights are used on Remy equipments. On the Reo the lamps are connected in parallel for bright lights and in series for dim lights. On the Velie and others, auxiliary small lamps are used for dim lights. On McLaughlin, Oakland and others a resistance is cut into the lamp circuit for dimming.

Remy on Oakland 34B

A wiring diagram of the Remy installation on the Oakland 34B is shown in Fig. 260. It is a three-unit single-wire 6-volt system, with the positive side of the system grounded. The output of the generator is regulated by a combination of the third-brush and thermostatic methods. The electromagnetic cutout is mounted on top of the generator. The ignition system is of the grounded type, and it, as well as the lights, is controlled by a combination ignition and lighting switch mounted on the dash. The headlights are dimmed by introducing a resistance in series with them, the lamps themselves being in parallel. An ammeter on the dash indicates the charge or discharge current of the bat-

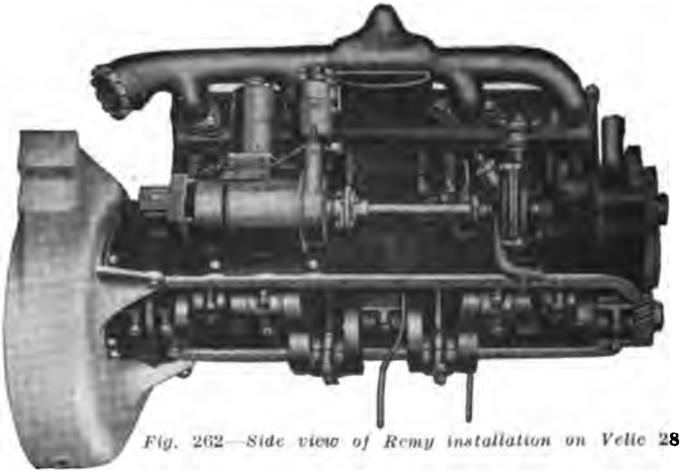


Fig. 262—Side view of Remy installation on Velie 28

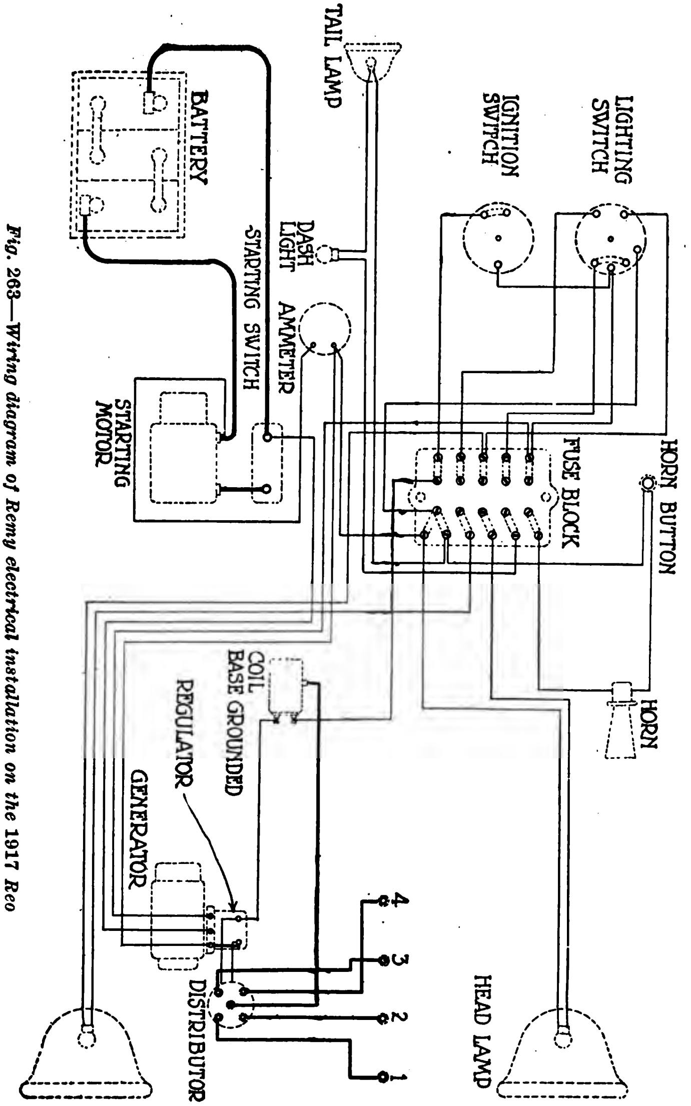


Fig. 263—Wiring diagram of Remy electrical installation on the 1917 Reo

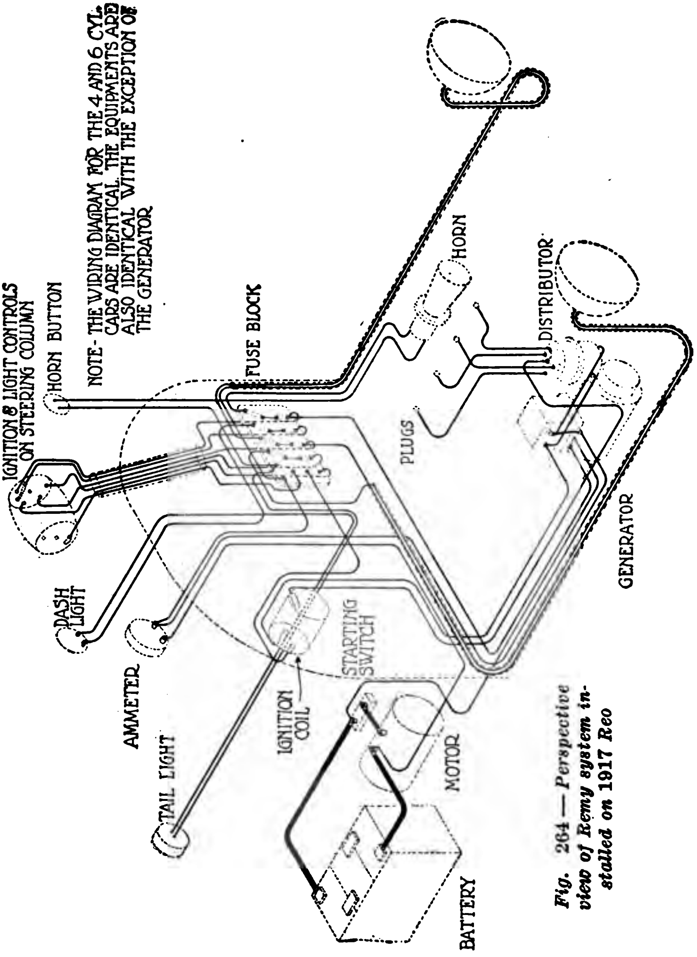

IGNITION & LIGHT CONTROLS ON STEERING COLUMN
HORN BUTTON
NOTE - THE WIRING DIAGRAM FOR THE 4 AND 6 CYL. CARS ARE IDENTICAL. THE EQUIPMENTS ARE ALSO IDENTICAL WITH THE EXCEPTION OF THE GENERATOR
FUSE BLOCK
HORN
DISTRIBUTOR
PLUGS
GENERATOR
DASH LIGHT
AMMETER
STARTING SWITCH
IGNITION COIL
TAIL LIGHT
MOTOR
BATTERY

Fig. 264 — Perspective view of Remy system installed on 1917 Reo

tery, except current taken by the starting motor. A Bendix drive is used in engaging and disengaging the starting motor with the engine automatically.

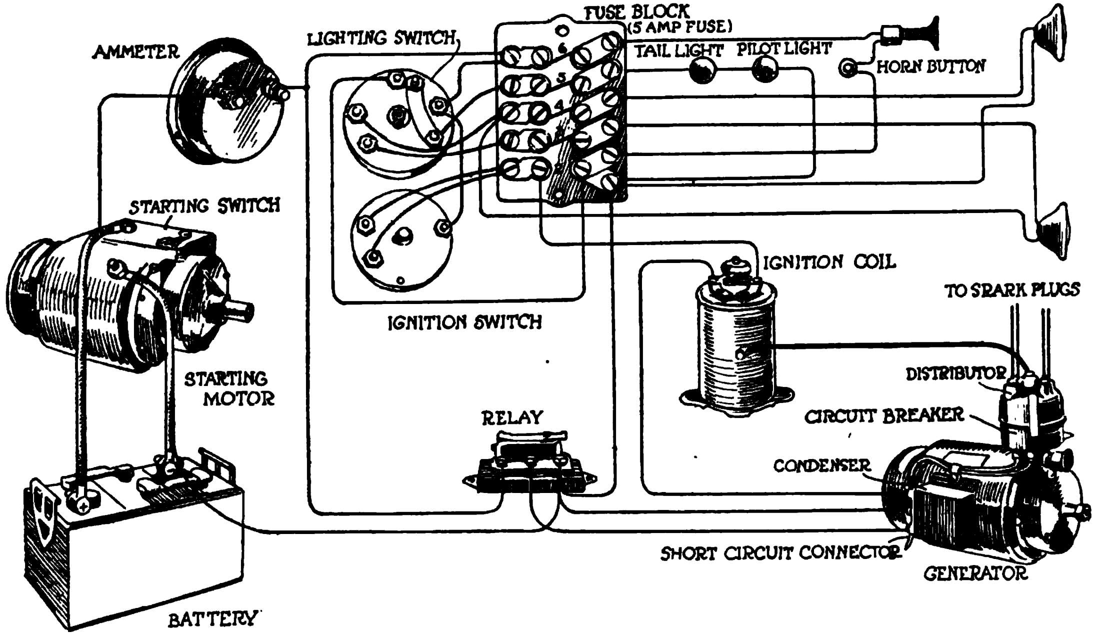


Fig. 265—Wiring diagram of Remy system on Reo, showing the different units

Remy Installation on Velie 28

A wiring diagram of the Remy installation on the Velie 28 is shown in Fig. 261. It is a two-unit single-wire, 6-volt system, with the positive side of the system grounded. The output of the generator is regulated by an electromagnetic regulator, which intermittently introduces a resistance in the shunt-field circuit. The combined regulator and electromagnetic cutout is located on the generator, also the ignition coil and ignition head, as shown in Fig. 254. The ignition system is of the insulated type. It is controlled by the combination ignition and lighting switch mounted on the dash. The ignition switch reverses the direction of the current through the breaker contact points each time the ignition is used, and in this way increases their life. Two sets of headlights are used. The installation on the Velie is clearly shown in Fig. 262.

Remy Installation on Reo Model R

A wiring diagram showing the connections of the Remy equipment on the Reo four-cylinder is given in Fig. 263, and a perspective view of the complete installation is shown in Fig. 264. This is a two-unit, 6-volt, two-wire system. The output of the generator is regulated by a combination of the third-brush and thermostatic methods. The automatic cutout or relay is mounted separate from the generator, as shown in the figure. The ignition system is of the insulated type, and it is controlled by an ignition switch mounted on the dash. All the different circuits are fused except the starting motor circuit. A pictorial wiring diagram of the installation is shown in Fig. 265.

Power is transmitted to the engine from the starting motor by a chain drive of Reo design and a ratchet engagement operated by the starting pedal.

CHAPTER XXV

Remy Tractor System

THE Remy apparatus used on the Moline-Universal D tractor consists of the governor-generator, control box, ignition distributer and the starting motor.

The generator, Figs. 265A, 265B and 265C, is four-pole shunt-wound. The armature, A, is assembled on a steel shaft on which the laminated core is built up, then the coils of insulated wire are wound on it, and their ends are soldered to the bars of the commutator, B. A gear is used on one end of the shaft, C, which engages with the camshaft gear, and the ratio is such that the

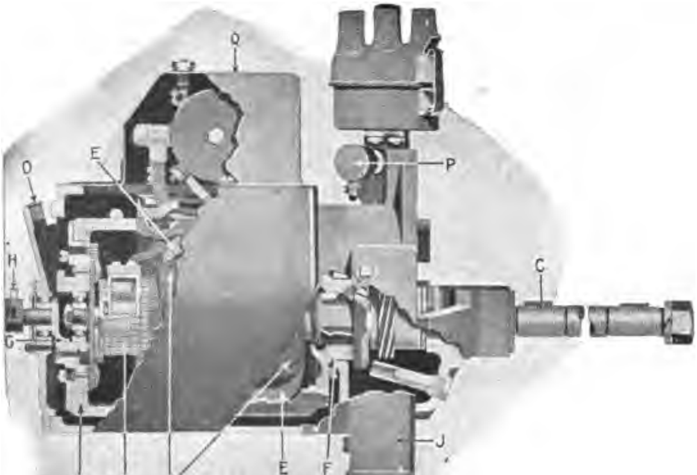


Fig. 265A—Side view of generator on Remy apparatus used on the Moline-Universal tractor

armature is driven one and a half revolutions for each revolution of the engine crankshaft.

The field frame, D, which has four poles around which the four field coils, E, are placed, is supported at the drive end by a bearing on the armature shaft in the casting, F. It is supported at the commutator end by the ball bearing supporting the forging, G. This field frame is free to turn through an arc of 30 degrees. The control lever, H, is attached to the shaft of G and is linked to the carbureter throttle, which it moves as the generator field frame D turns.

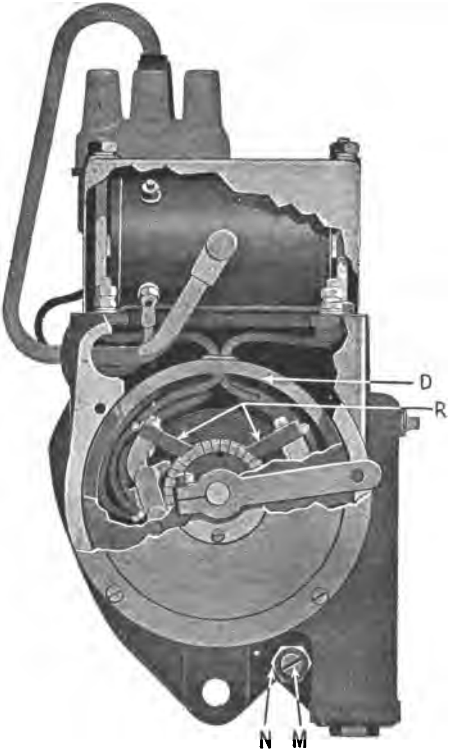


Fig. 265*B*—*End view of generator on Remy apparatus used on the Moline-Universal tractor*

A spring, I, is provided, which tends to turn the field frame in a direction opposite to the armature rotation. This governor serves the double purpose of inclosing the spring and a dashpot cylinder. The dashpot is a part of the drive end head casting J. The piston K, working up and down in oil in the dashpot, serves to prevent the too rapid fluctuation of the field frame to which it is linked.

The field rheostat, which is in the control box, is a resistance unit. It is composed of a length of German silver wire with ten contacts so arranged that connection may be made to any contact by a movable contact arm. The contact arm is carried on a shaft extended through the face of the control box and to which is attached the rheostat hand wheel, affording a convenient method of controlling the contact arm. The ten positions of the hand wheel shown on the face of the control box indicate the ten steps of resistance in the rheostat.

Position No. 1 gives a governed engine speed of approximately 400 r.p.m., while position No. 10 gives a governed engine speed of approximately 18 r.p.m.

Any engine speed attained by placing the controller on a given position will be maintained because if the engine speeds up, due to a decrease in load, the magnetic pull of the field on the armature is increased, causing the field frame to turn and close the throttle. But if the engine slows down, due to an increase in load, the magnetic drag of the field on armature is decreased, allowing the field frame to be turned by the spring in the direction opposite to armature rotation, opening the throttle.

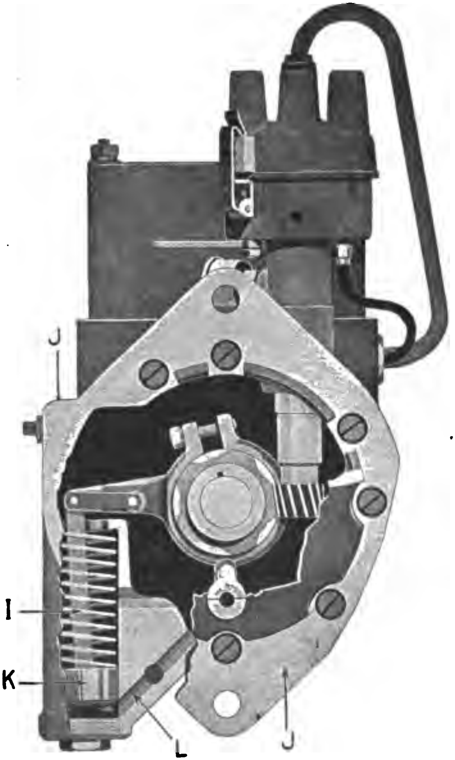


Fig. 265C—Another view of the generator used in Remy tractor apparatus, showing generator spring

The oil dashpot and piston prevent the spring from opening the throttle too quickly. The dashpot is exposed to the oil of the engine case and, therefore, needs no attention.

When the throttle is opened the oil is forced by the piston from the dashpot through a by-pass, L. The size is controlled by an adjustable screw, M, with locknut.

To adjust dashpot by-pass valve, loosen locknut, turn screw M to left four turns, place controller on position 8, then change quickly to position I. If the governor fluctuates up and down, turn screw to right until the fluctuation is eliminated.

Do not adjust until the engine is warm and the carbureter is known to be all right.

To oil the governor-generator, put four drops of 3-in-1 or cream separator oil in the ball oil hole O twice a week. Turn down the grease cup two turns a week. Too much oil or grease is bad. Do not use gas engine or farm machinery oil on electrical apparatus.

A removable dust-tight cover, Q, at the top of the generator case provides access to the commutator and brushes. Inspection of brushes, R, and commutator, B, for dirt should be made twice a season. The commutator wears naturally to a brownish color in normal use, but if it appears black or scored, the surface should be smoothed with a piece of fine No. 00 sandpaper. Never use emery cloth for this. Blow out all dust and clean out all dust between commutator bars. See that the brushes swing freely on their pivots, so that the spring tension holds them in good contact with the commutator.

To produce a spark at the spark plug it is necessary to close and open the battery circuit through the ignition coil each time, and this action is accomplished by the circuit breaker. The circuit breaker has two contact points, one, the contact screw for adjusting the breaker point opening, being stationary, while the other is carried at the free end of a pivoted arm called the breaker lever. The four-faced rotating steel piece, called the cam, has accurately ground corners which bear against the fiber block in the arm as the cam turns and cause the contact points to open and close at the proper time.

To adjust the contact points turn the engine until the contact points are wide open. The gap then should be 0.020 to 0.025 in., or the thickness of the gage on the side of the wrench furnished for adjusting the contact point opening. If found to be worn unevenly or dirty, these may be cleaned by passing between them a fine flat file or, preferably, a piece of No. 00 sandpaper. Do not use emery cloth.

Adjustment of the gap between the contacts is made by loosening the locknut next to the post with the wrench furnished, turning the adjusting screw and then locking the nut again. Do not oil these contact points. Every week, however, a slight trace of vaseline placed on the fiber block or on the cam will keep the cam from rusting and wearing the fiber block.

Starting Motor

The starting motor is of the four-pole, series-wound type with Bendix drive. The position of the rocker ring, on which the brushes are mounted, never should be changed, as the ring is set accurately at the factory.

Maintenance and Operation

Do not crank the tractor by hand with the spark advanced.

Keep out dirt when adjusting the breaker points.

Avoid excess lubrication on the breaker box—oil or carbon on the breaker points will prevent a spark.

Do not play with the generator. It is tested thoroughly and its adjustment should not be changed.

If trouble is experienced, such as weak lights, sluggish starter or poor ignition, examine all terminals to see that they are tight and clean, especially the storage battery terminals. They should be kept free from all corrosion.

Do not remove the ignition distributer from the governor-generator housing, unless necessary, because it will change the timing.

Do not change the ignition timing, unless it is absolutely necessary, due to having removed the ignition distributer or governor-generator from the engine.

Do not hold the carbureter throttle open and cause the engine to race when the control is on a low point, as the field then will be strong, permitting the voltage and output to run up very high and possibly burn the rheostat resistance in two. Then there would be no control of the engine speed, as the field circuit would be open and no current could be generated to operate the governor.

Under proper conditions, the engine should start after 1 to 3 sec. cranking. If it does not start after 10 to 15 sec. cranking, something is wrong. Investigate before cranking further or the battery soon will become discharged.

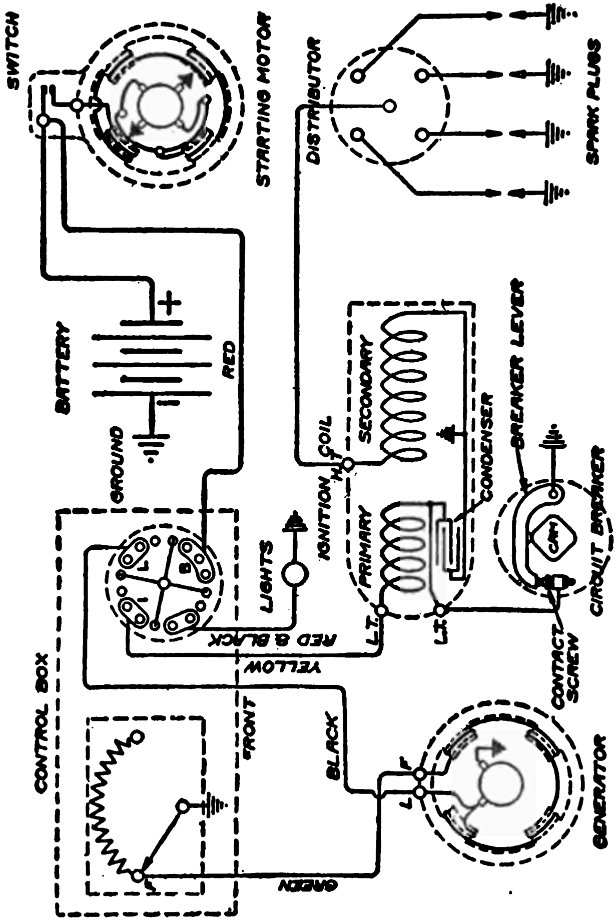


Fig. 265D—Wiring diagram of Remy installation on Moline-Universal tractor

If the starter fails to crank the engine, do not blame the starter, ignition or the carbureter, but proceed as follows:

1—See that the battery terminals are clean and that all connections in the starting circuit are tight, especially the starter lead where it is soldered into the terminal that connects it to the battery. If you are able to twist the wire in the terminal, it should be re-soldered.

Note if a flash occurs at the starter switch contacts when releasing the switch.

a—If it does not, or is very weak—that is evidence of a very weak battery or poor connections.

b—If a good flash occurs and the starter does not turn the engine, remove the commutator cover and see if the armature is free to turn with your finger.

c—If it is and the armature turns when the switch is closed, the trouble is, no doubt, due to heavy grease on the Bendix screw shaft, which prevents the pinion from going into mesh with the teeth in the flywheel.

d—The starter is not intended to crank the engine without first gathering a little momentum made possible by the time required for the pinion to travel into mesh with the flywheel gear teeth. Therefore, if you close the starter switch momentarily and the starter does not have time to turn one cylinder past compression, the Bendix pinion will very likely stay in mesh with the flywheel gear and the next time you try to use the starter, it will be trying to start with a dead load.

You would not think of starting the engine with the tractor in gear and the clutch connected, as the load would be too great. Therefore, do not try to start the engine with the Bendix pinion in mesh.

e—If the battery is nearly discharged and the lights are turned on, they will be dim when the starter switch is closed. The lights will also be dim if you try to use the starter when the Bendix pinion is standing in mesh with the flywheel gear.

If the battery is so low there is not enough current for ignition to start the engine, then proceed as follows:

1—Remove the line wire from terminal L under the generator cover and be sure the terminal does not touch any metal, thereby causing a ground.

2—Place the control on point 5 or 6.

3—Turn the ignition key to "on" position for daylight running.

4—Do not use the starter, but crank the engine by hand and do

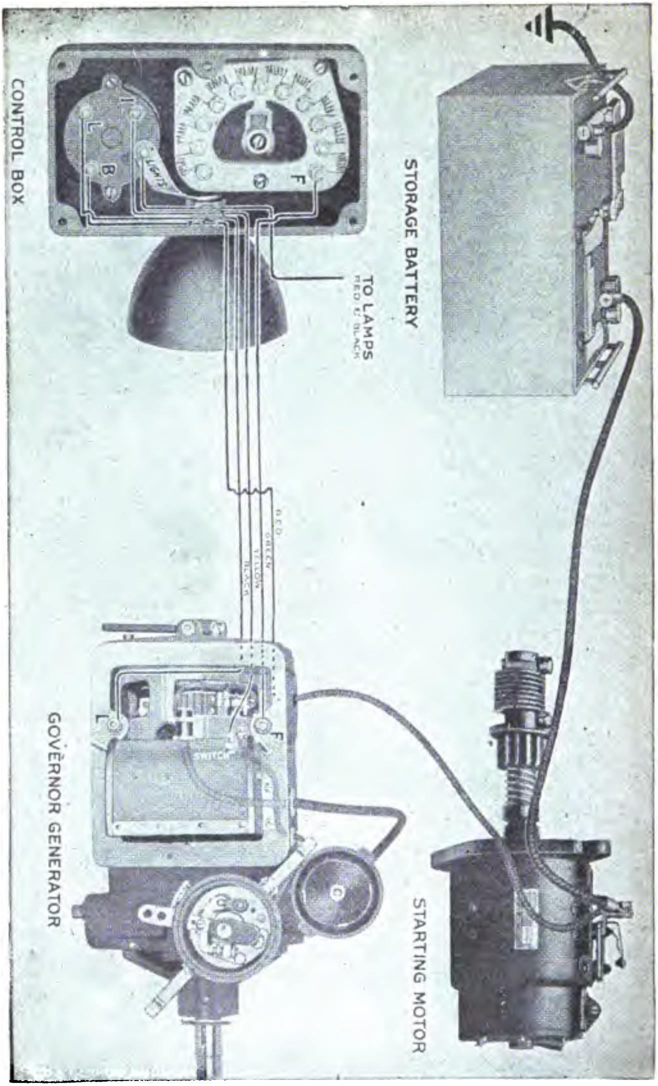


Fig. 265E—Connections of Remy electric installation on Moline-Universal tractor

so as soon as possible after turning the switch on. If there is no trouble other than a low battery, the engine will start and run slowly until the line wire is replaced on terminal L, unless the battery is completely discharged, in which case:

a—Turn the switch to "off."

b—Repace the line wire on terminal L under the generator cover.

c—Connect three to five cells, depending upon their condition, in parallel with the ignition circuit from the terminal marked "switch" on top of the ignition coil to a convenient ground, preferably the circuit breaker control lever.

d—Crank the engine by hand.

5—As soon as the engine starts, turn the ignition key to "on" position and after the engine runs a few seconds, disconnect the dry cells, as the generator will furnish enough current for ignition and for charging the storage battery.

6—After having to crank the engine by hand, the engine should be run for about half an hour at a speed of approximately 675 r.p.m. to put a little life into the storage battery before trying to do actual work.

So long as you get good ignition and good governing, you can rest assured the battery is being charged, as it is the charging that does the governing.

Recharging the Battery

To recharge the battery quickly, without removing it from the tractor or running the engine fast, proceed as follows:

1—Place the control on point 1.

2—Turn the carbureter valve stop screw one full turn to the right.

a—The engine will then run approximately 675 r.p.m. and should be charging the battery at about 6.5 amp.

b—The generator should not be run for even an hour with an output greater than 8 amp.

Running the engine as suggested above for 2 or 3 hours should bring the battery up to a point where it would operate the starter, unless it had been completely discharged, in which case 6 hours, or longer, may be required.

A loose connection anywhere in the line or a corroded battery terminal very likely will prevent recharging of the battery and cause overheating of generator and possible damage, in which case it will soon become discharged.

After recharging the battery, be sure to return the screw to original position to avoid injuring the storage battery or other equipment.

The ball joints in the linkage between the carbureter and the governor lever should work freely. Therefore, they should be kept clean and be oiled often to prevent rusting.

Testing the Generator

To test the generator, put an ammeter in series with the battery by disconnecting the line wire from terminal L under the generator cover and connecting it to one side of an ammeter. Then run a wire from the other side of the ammeter to terminal L.

If after making these connections the ammeter hand shows charge with the switch on and the engine not running, you will know that the wires on the ammeter should be reversed.

If the ammeter does not show a discharge of about 15 to 20 amp. when the engine is not running and the switch is turned to "on" or "run" with the control on point 1, look for the following:

1—A weak storage battery.

2—A corroded storage battery terminal.

3—A ground or short-circuit in the starting motor switch or somewhere in the wiring between the ammeter and the storage battery.

4—A poor ground or poor connection between the control box and the tractor frame or in the wiring.

5—Poor contact between the control handle and the control box or the contact spring and the contacts to which the rheostat resistance is connected.

6—Loose or dirty connections at the terminal posts in the control box, starting motor switch, under the generator cover or where the wire is soldered to a terminal.

7—If all but a few strands of the wire are broken off at the terminal, a new connection should be made and soldered.

8—Sometimes all or most of the strands of wire are broken inside of the insulation at a point where the wire is subject to much movement. This condition can usually be determined by feeling the wire. In such cases, the wire should be cut at the point where it is bad, cleaned well, twisted together, soldered and taped well or a new piece of wire used with terminal properly resoldered.

9—A poor contact in the combination lighting and ignition switch. If the discharge rate is much more than 20 amp., look for the following:

a—Broken down insulation at terminal post "L," due to a crack in the insulation, dirt or the insulating bushing being out of place, causing a short circuit.

b—Line, insulated brush or leads connected to it may be shorted.

c—Grounded or shorted field.

If the discharge rate does not decrease as the control is turned toward point "Fast" and stands at about 15 to 20 amp., you can be sure that the trouble is due to short-circuit somewhere between the field winding where it is connected to post F under the generator cover and post F inside of the control box.

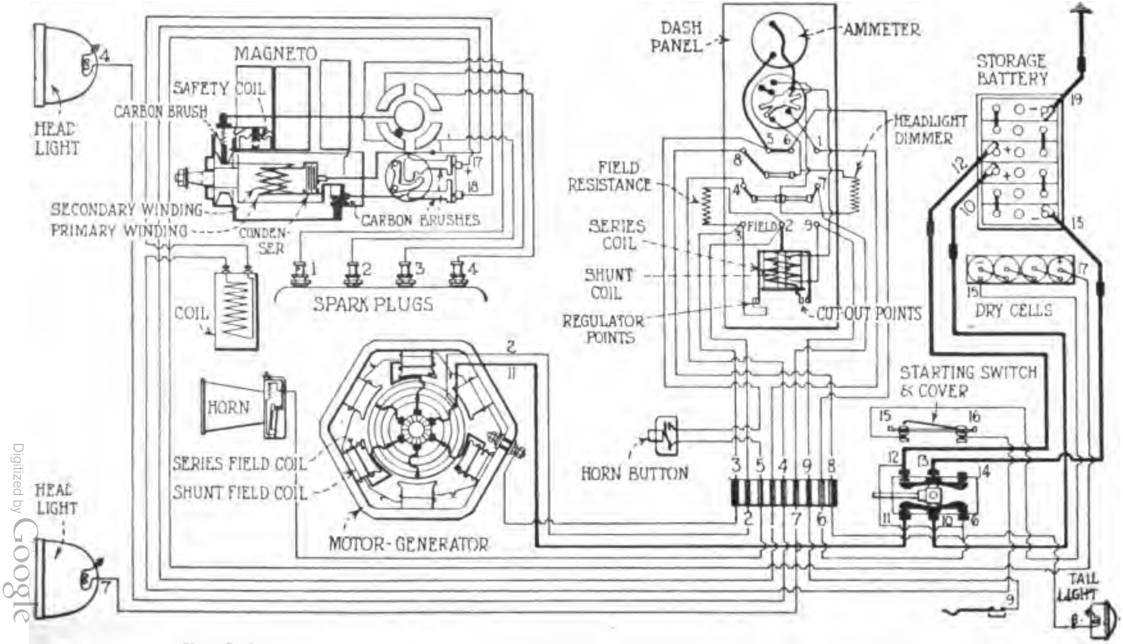


Fig. 266—Wiring diagram of Simms-Huff installation on the 1916-1917 Maxwell

CHAPTER XXVI

Simms-Huff Electrical Systems

THE Simms-Huff electric starting and lighting systems used on 1915, 1916 and 1917 motor cars are two-unit systems in which the starting motor and generator are combined in a single machine. This electrical unit usually is mounted on the left side of the engine. It is connected mechanically to the engine by a sliding pinion when it is operating as a starting motor and driven by a belt from the engine when it is operating as a generator. The electrical unit is a six-pole machine, and a shunt winding is provided on all six poles and a series winding on three of the poles. The battery used with these systems consists of two sections, and each of these sections is made up of three cells in series. The two sections of the battery are connected in series by a special starting switch when the electrical unit is operating as a motor and in parallel when the starting switch is in its normal position. When the electrical unit is operating as a motor, the shunt and series fields assist each other in producing turning effort and thus increase the torque of the motor. When the electrical unit is operating as a generator the shunt and series fields are opposed to each other in their magnetizing actions, and the output is not excessive at the higher speeds.

The systems all are of the grounded, or single-wire, type with the negative terminal grounded. The regulation of the generator output is by a reversed series field in combination with a regulator of the constant-voltage type. The regulator is combined with the cutout and mounted under the left front seat on 1915 cars. On 1916 and later cars the combined cutout and regulator is carried on a cowlboard panel, together with the lighting and ignition switch, the ammeter and the fuse panel. The equipment on the 1917 motor cars differs very little from the equipment found on the 1916 cars. A current indicator is

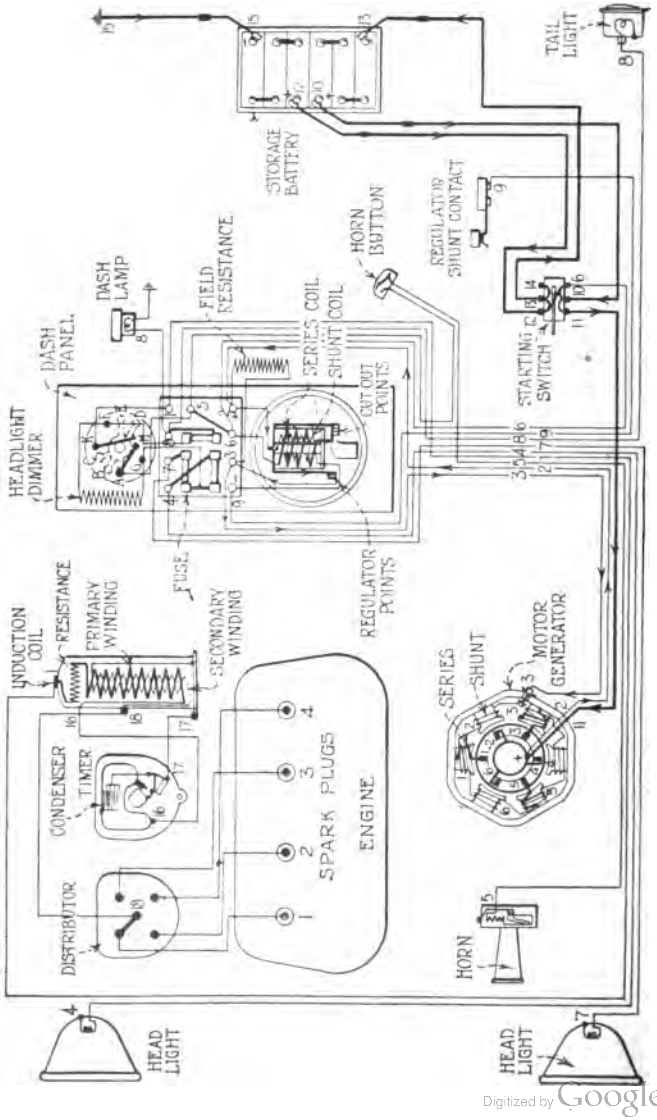


Fig. 267—Wiring diagram of Simms-Huff installation on 1917 Maxwell, starting switch closed

used instead of an ammeter, and the arrangement of the fuses is somewhat different.

The earlier 1917 cars used magneto ignition, while the later 1917 and 1918 cars use the Atwater Kent ignition system. The various parts of the magneto and Atwater Kent ignition systems are shown in Figs. 266 and 267.

The cutout is of the electromagnetic type, and the circuit of the shunt winding is opened at the starting switch when the starting switch is closed for motor action so as to prevent the winding from being connected to the 12-volt battery.

Simms-Huff for 1918

The Simms-Huff electrical equipment on 1918 cars is a single-voltage system, the battery being composed of six cells in series and having the negative terminal grounded. The starting motor and generator actions are performed by the same electrical unit, and the construction and regulation of the output of this unit is practically the same as the one used on the 1915, 1916 and 1917 cars. The starting switch is very much simplified, and it has only two contacts. The starting switch is operated by a pedal which also serves to throw the starting gears into mesh.

A very unusual feature of this starting switch is a special lock operated by an electromagnet. The operation of this lock is such that it prevents the starting switch from being closed and, hence, also prevents the starting gears from being thrown into mesh while the engine is running. This special lock consists of a solenoid mounted on the forward end of the switch. The solenoid has a movable core and is held against the rod which carries the starting switch contact piece by a spring. A notch is cut in the rod, and the end of the core of the solenoid fits in the notch and thus prevents any motion of the rod and, hence, holds the switch open. The circuit through the solenoid, in starting, is completed by pressing a button on the heelboard beside the driver, which draws the core away from the rod and allows the starting switch to be closed and the starting gears to be meshed.

The winding of the solenoid is short-circuited when the cutout closes, and it is impossible to operate the starting switch after it is released. It is impossible to operate the solenoid even if the cutout opens and the engine continues to run, as the voltage applied to the solenoid winding when the cutout is open is the difference between the battery voltage and the voltage generated in the armature of the electrical unit, which is usually too small to energize the solenoid.

Installation on 1917 Maxwell

A two-unit, single-wire, 6- and 12-volt system is used on the 1917 Maxwell. A wiring diagram showing all the various internal connections is given in Fig. 267. The ignition, starting, and charging circuits may be traced by following this diagram.

By inserting the ignition key in the lighting and ignition switch the ignition circuit is closed. The ignition primary current for starting the engine is supplied by both halves of the storage battery, connected in parallel, and is delivered to the ignition switch from terminal No. 6 on starting switch to No. 6, on the fuse block, the remainder of the primary circuit being as follows:

From terminal No. 6, on fuse block to terminal No. 5 on the fuse block, to point A on the back of the lighting switch, from point A to point H on the back of the lighting switch through the ignition switch contact spring to point K on the back of the lighting switch and to terminal No. 1, on the fuse block; from terminal No. 1 on the fuse block, through the circuit No. 1 to the terminal No. 1, on top of the induction coil, through the primary winding of the induction coil to point No. 16 on the coil, to terminal No. 16 on the condenser cover at the timer.

From terminal No. 16 on the condenser cover the current flows through the condenser cover—shown in outline—to the timer breaker points, and from the timer breaker points to point No. 17 on the timer, the contact breaker spring serving as the conductor. Point No. 17 on the timer to point No. 17 at the base of the induction coil and ground completes the circuit. Under running conditions, when the speed of the generator is such that the voltage generated closes the cutout points for charging the storage battery, the ignition primary current is supplied directly from the generator to terminal No. 2, on the fuse block across the cutout points through the regulator to terminal No. 6, on the fuse block from which point the circuit is the same as under starting conditions.

A condenser is connected directly across the breaker points, and while no steady current flows through it, it is an absolute necessity to get the proper performance of the induction coil. At the instant the timer breaker points separate a high-tension current is induced in the secondary winding. This high-tension current leaves the induction coil at terminal No. 18.

The high-tension current circuit can be traced from terminal No. 18 on the induction coil to the center terminal No. 18 on the distributer cover, where it is distributed to the separate spark plugs, across the spark plug gap to the ground and thence back to the secondary winding.

Under starting conditions the starting switch plunger is moved forward and completes the circuit between 12 and 13 and between 11 and 10, the same movement meshing the starter pinion with the flywheel teeth. The path of the current will then be as follows: Starting at the storage battery, from terminal 12 to terminal 12 on the starting switch; from 12 to 13 through the starting swich contacts; from 13 on the starting switch to 13 on the storage battery; through the storage battery to 10; from 10 on the storage battery to 10 on the starting switch; from 10 to 11 through the starting switch contacts; from 11 on the starting switch to 11 on the electrical unit, that is, terminal marked +; from + terminal on the electrical unit to brushes 2, 4 and 6; through the armature windings to brushes 1, 3 and 5; through the series windings on the respective pole pieces to the ground.

The windings on the six shunt coils pick up current as follows: Starting at the + terminal on the electrical unit, through circuit No. 2 to No. 2 + terminal on the fuse block; from there through the regulator arm, and across the regulator points, which at this time make a full contact; and back to field terminal No. 3 on the fuse block. From there following circuit No. 3 back to the terminal No. 3 on the electrical unit frame. From this point through the six shunt coils to ground on the pole piece No. 3. The return circuit is from ground No. 15 on the frame to terminal No. 15 on the storage battery.

On releasing the starting pedal the starting switch plunger comes all the way back and makes connection between 13 and 14 and 10 and 6 on the starting switch. In the meantime the terminal voltage of the generator has built up and the shunt winding of the cutout and regulator has become energized

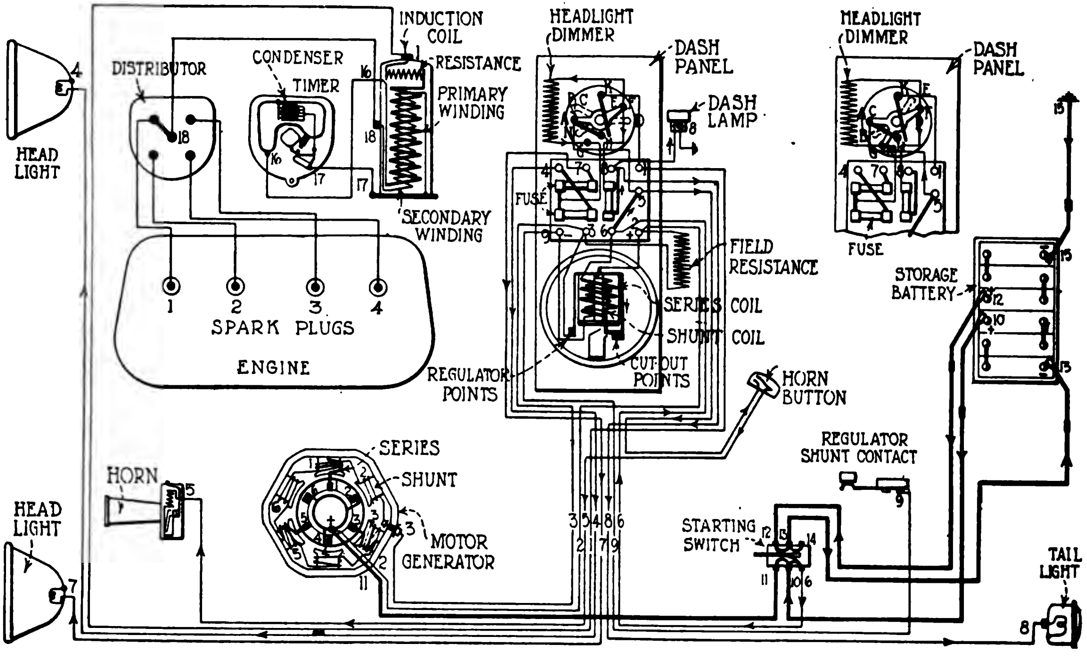


Fig. 268—Wiring diagram of the Simms-Huff on the 1917 Maxwell, two positions of lighting switch

through circuit No. 2 from the generator positive to the fuse block, No. 2, and through the shunt winding to terminal No. 9. From here the current passes to terminal No. 9 on the regulator shunt contact, which is a grounded connection. In the starting position this ground contact, No. 9, is broken so that the regulator will not become energized at the point of starting. As soon as the voltage reaches a predetermined point, the magnetizing action of the shunt winding will cause the cutout points to close and the panel indicator to show "Charge."

The charging circuit will then be as follows: Starting at the + terminal on the electrical unit, follow circuit No. 2 to No. 2 on the fuse block, from there through the cutout arm, across the cutout points, through the series winding of the relay to terminal No. 6, on the fuse block. From this point follow circuit No. 6 to terminal No. 6 on the starting switch, through the switch contact and No. 10 to No. 10 on the storage battery, through the storage battery to No. 13 to No. 13 on the starting switch, through contact to No. 14, which is grounded. At the same time follow circuit No. 6 through the permanent connection to No. 12 on the starting switch, thence to No. 12 on the storage battery, through the battery and No. 15 to No. 15 on the frame, which is grounded. Grounded connections No. 14 and No. 15 complete the circuit to the motor generator frame.

Regulation is accomplished by the vibrator points of the regulator alternately cutting in and short-circuiting the field resistance on the dash panel. With regulator points closed, the field circuit of the generator is from terminal No. 2, on the fuse block, through the regulator arm; across the points to terminal No. 3, on the fuse block. From here folow circuit No. 3 to No. 3 on the electrical unit; through the shunt windings to ground on pole piece No. 3. With the regulator points open the field circuit is from terminal No. 2, on the fuse block through the field resistance to terminal No. 3, on the fuse block and follows circuit No. 3 as before.

The lighting circuits may be traced by reference to Fig. 268. The lighting switch spider is shown in the off position in Fig. 267 with spider arm N in contact with point A on the back of the lighting switch and with arms, B, C, D and E free. The lighting switch spider in the complete dash panel of the diagram above is in the dim position. In this position, spider arm B is in contact with point A, arm E is in contact with point F, and arms C, D and N are free.

When the generator is not charging the storage battery, current is supplied to the lighting and horn circuits by the storage battery and is delivered to the switch panel from terminal No. 6 on the starting switch to terminal No. 6, on the fuse block through the bus bar to terminal No. 5. When the generator is charging the battery, current is supplied by the generator to terminal No. 2, on the fuse block, across cutout points, through the series coil of the regulator to terminal No. 6, on the fuse block and as before to terminal No. 5.

The lighting circuit with the spider in dim position is from terminal No. 5, to point A on the lighting switch, through spider arms B and E to point F on the lighting switch. The headlight circuit is then from point F on the lighting switch through the headlight dimmer coil to point G on the lighting switch, to the center of the bus bar connecting the right and left headlight fuse clips, through the fuses to terminals No. 4 and No. 7, right and left headlights, respectively, through circuits No. 4 and No. 7 to right and left headlamps, respectively, and to ground. The tail lamp circuit is from the point F on the lighting switch to the tail lamp fuse, through the fuse to terminal No. 8, on the fuse block, from terminal No. 8 on the fuse block to the dash lamp and ground, also through circuit No. 8 to the tail lamp and ground.

The portion of the panel shown to the right of the complete panel shows the spider in the on position. The spider arm C is in contact with point A, arm N in contact with point G and arm D in contact with point F, arms B and E being free.

The lighting circuit is now from terminal No. 5, on the fuse block to point A, through the spider arm C as before. Headlight current follows the circuit through spider arm N to point G and to headlights from point G as before. Tail light current follows the circuit through the spider arm D to point F and to tail and dash lamps as before.

The electric horn circuit is as follows: Starting at terminal No. 6, follow the bus bar to terminal No. 5, through circuit No. 5 to horn button and to the insulated terminal on

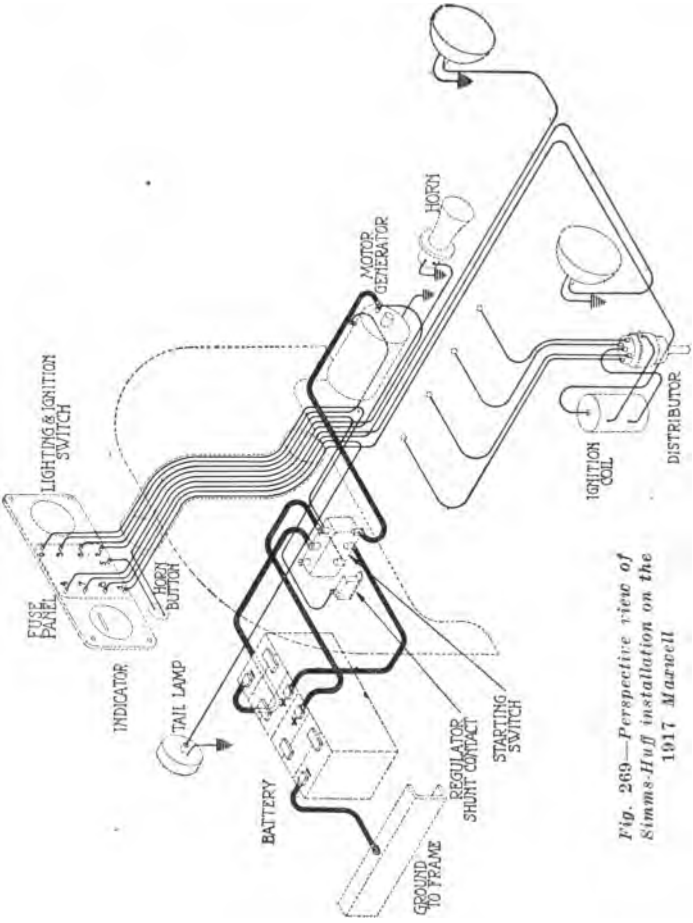


Fig. 269—Perspective view of Simms-Huff installation on the 1917 Maxwell

the horn, through the magnet winding of the horn across the contact points to ground and thence to the storage battery.

A perspective view of the electrical installation is shown in Fig. 269 and a simplified wiring diagram is shown in Fig. 270.

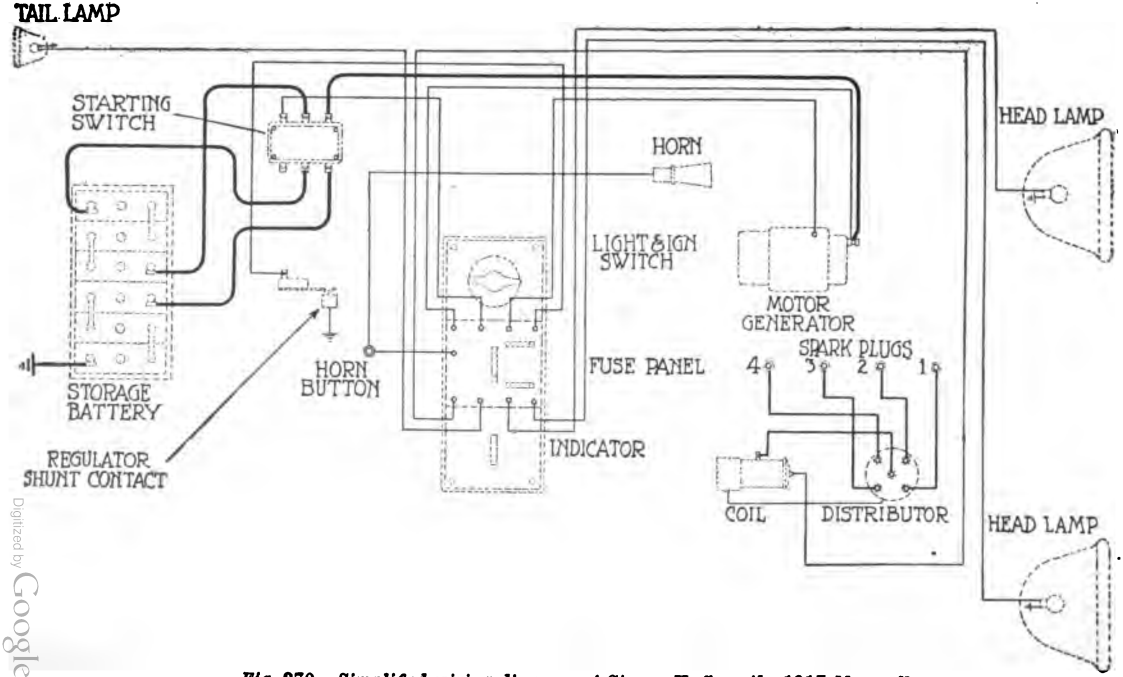


Fig. 270—Simplified wiring diagram of Simms-Huff on the 1917 Maxwell

Ignition on 1917 Maxwell

A diagram of the ignition system used on the 1917 Maxwell cars is shown in Fig. 271. The circuit diagrams are shown in Figs. 267 and 268. A diagram of the magneto system used on earlier models is shown in Fig. 272.

The high-tension current for ignition is produced by the action of a non-vibrating coil on the low-tension current delivered by the generator under running conditions and by the storage battery under starting conditions. The low-tension current is delivered through the starting and ignition switches to the top of the induction coil, which is located on the base of the ignition unit.

The high-tension current is distributed to the respective cylinders by an Atwater Kent ignition unit located on the right side of the engine and driven by the engine timing gears. The distributer block which fits over the end of the timer shaft delivers the high-tension current to the brass segments, which are

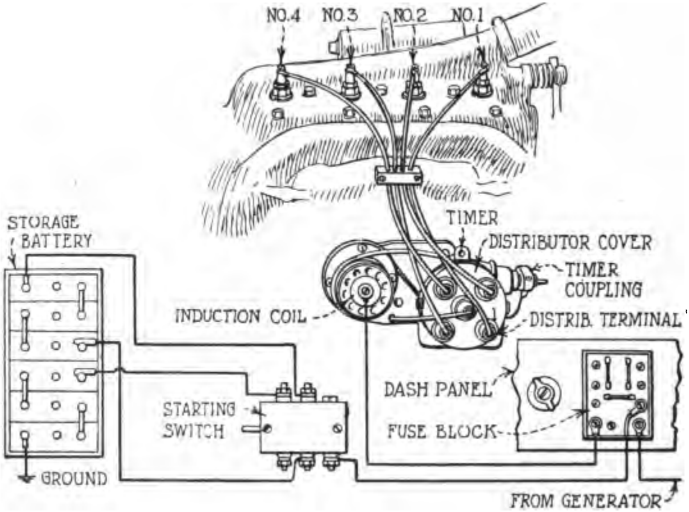


Fig. 271—Wiring diagram of Atwater Kent ignition system on the Maxwell

permanently embedded in the distributer cover, then through the high-tension wires to the spark plugs. The distributer block just clears the distributer segments without actually touching them.

When starting the engine the spark should be fully retarded to eliminate the possibility of backfiring. At medium or high speed the best results are obtained with the spark partly or fully advanced.

Never under any condition leave the switch key in the switch when the engine is not running as the storage battery will discharge.

The ignition is properly timed to the crankshaft when the car leaves the factory, and unless the ignition unit, driveshaft couplings or timer drive gear has been removed from the engine, there should be no necessity to retime the ignition. However, if the ignition driving mechanism has been removed or disturbed for any reason, exercise care in replacing all parts so removed or

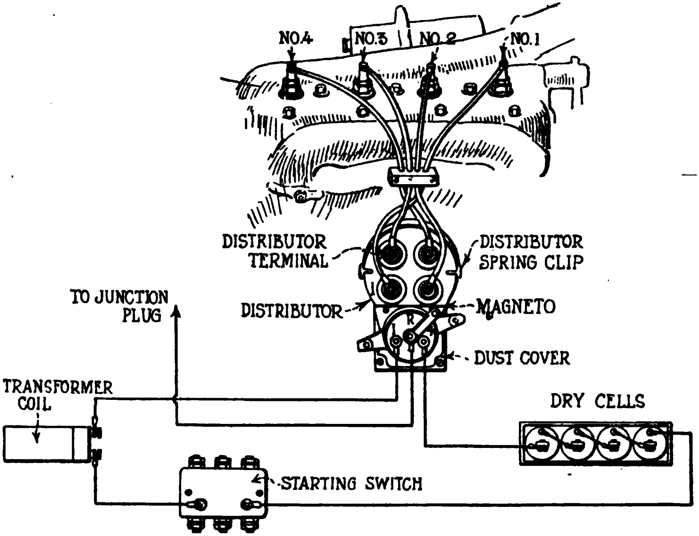


Fig. 272—*Wiring diagram of Simms high-tension magneto on the Maxwell* disturbed. On the rear end of the timer driveshaft will be found a punch mark. This punch mark and the slot in the timer driveshaft coupling should be assembled in line and on the same side of the driveshaft center. The timer drive gear and camshaft gear are punch-marked with a double mark on the tooth of the former and between the teeth of the latter, and in assembling gears these double marks should be together while single marks on the crankshaft gear and camshaft gear are together. When the gears are so assembled, No. 1 piston should be in firing position and the slot in the timer driveshaft half of the coupling should be up.

In connecting the ignition unit to the timer driveshaft coupling the following applies when timer drive gear, shaft and shaft coupling are assembled properly. If the coupling has not been loosened on the timer coupling shaft, turn the crankshaft with the hand crank until No. 1 piston is $\frac{1}{32}$ in. past top dead center, or 1¼ in. past on the flywheel, on compression or firing stroke. Remove the distributer cover, which is held in place by two spring clips, and turn the timer coupling shaft until the distributer arm is brought into position opposite No. 1 segment in the distributer cover. The front right terminal on the distributer cover is No. 1. Turn the timer coupling shaft to the right or left until the coupling pin is in a position to engage in the driveshaft coupling notch. With the timer in this position couple it to the engine, bolt to bracket and connect the termnals in the proper firing order of the engine, namely, from left to right, or clockwise, 1-3-4-2.

If the coupling has been loosened on the timer coupling shaft, place No. 1 piston and distributer arm in position as explained. Retard the breaker and turn the timer coupling shaft by the knurled collar until the platinum points just break, or in other words, just separate. Hold the coupling shaft in this position, turn the coupling on the shaft until the coupling pin is opposite the notch in the driveshaft half of the coupling and tighten the coupling clamp screw. Couple the timer to the engine and connect the terminals as previously explained. Exercise care in connecting the terminals. Be sure that they are tight and secure, and do not allow any of the high-tension cables to rub or chafe on any metallic part of the engine or car.

CHAPTER XXVII

Westinghouse Electrical Systems

NUMEROUS different types of electrical equipment for the motor car manufactured by the Westinghouse Electric & Mfg. Co. are in use. In the majority of these installations the single-wire system is used, and the positive side of the system is grounded in practically all cases, if the system is grounded at all. In some systems the generator and motor actions are combined in a single machine, while in the majority of cases they are taken care of by separate machines. The systems in which the generator and motor actions are combined in a single machine are the 12-volt type, and in the majority of cases the two- and three-unit systems are of the 6-volt type. In some cases the ignition is combined with the generator, and in some it is taken care of separately.

The starting motors are all quite similar in their electrical

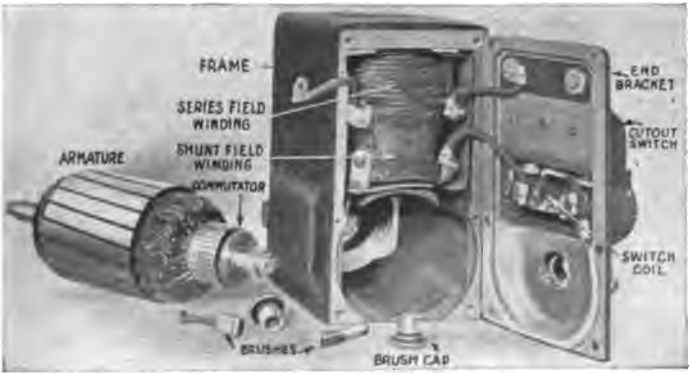


Fig. 273—Westinghouse generator with reversed series field regulator and internally mounted cutout

operation, but quite a number of different methods are used in transmitting power from the motor to the crankshaft of the engine, and in this way there is quite a wide variation in their construction. Several different types of starting switches are used and they will be described briefly in one of the following sections. The lighting switch is usually of the push-button type. All the various circuits are fused by cartridge fuses mounted in fuse boxes or compartments provided for them.

Reversed Series Field Regulation

Exploded views of two generators with reversed series field regulation are shown in Figs. 273 and 274. The automatic cutout is mounted inside of the frame of the generator shown in Fig. 273 and in the case of the generator shown in Fig. 274 the cutout is mounted outside the frame of the generator. The internal connections of the generator shown in Fig. 273 are given in the diagram in Fig. 275, and its operation, as well as the operation of the generator with an external cutout, is as follows:

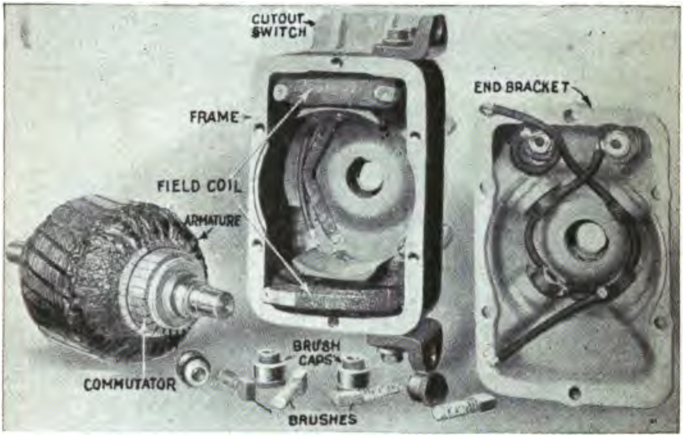


Fig. 274—Westinghouse generator with reversed series field regulator and internally mounted cutout

As the speed of the generator builds up its voltage increases, and finally sufficient current is produced in the shunt winding of the cutout to produce ample pull on its armature to close the cutout contacts. When the cutout contacts close the generator immediately starts to deliver current, provided its voltage exceeds the voltage of the battery, which should always be the case when the cutout contacts close. If no lamps are turned on, the current delivered by the generator will pass through the series winding of the generator and charge the battery. The direction of this current is such that its magnetizing action opposes the magnetizing action of the current in the shunt field winding and the generator operates as a differential compound generator. This differential action of the series field tends to prevent the output of the generator from increasing as rapidly as it otherwise would do.

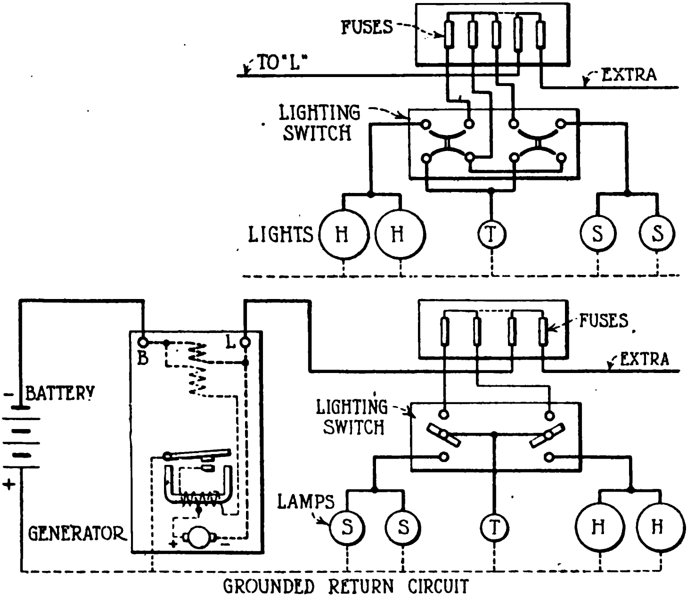


Fig. 275—*Internal connections of Westinghouse generator shown in Fig.* 273

If some current is being supplied to the lamps and this current is less than the generator current, then the current in the series winding will be equal to the generator current minus the current taken by the lamps, and the demagnetizing action of the series field will not be as great as it was in the previous case, which results in the generator output increasing a little more rapidly. If the lamp current exceeds the generator current, the battery will have to assist the generator, and the current in the series field

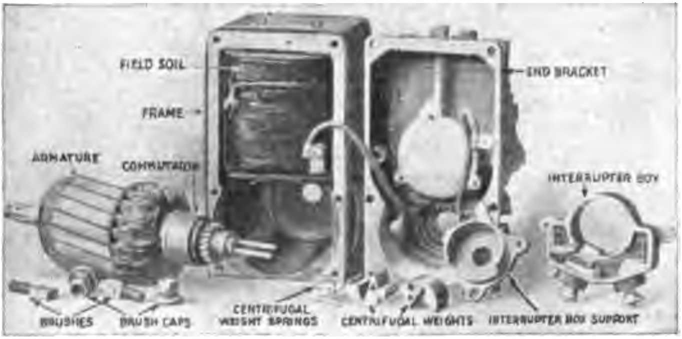


Fig. 276—Westinghouse ignition and lighting generator with reversed series field regulation

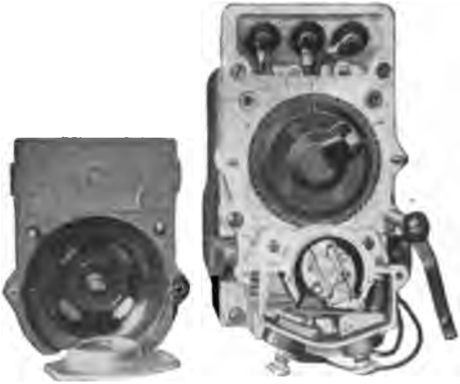


Fig. 277—Exploded view of ignition end of Westinghouse ignition and lighting generator

will be in the reverse direction to what it was in the preceding cases. The magnetizing action of the series field will assist the magnetizing action of the shunt field and the generator will operate as a cumulative compound generator. It is thus seen that as the lamp load increases the magnetizing action of the series field is changed, and this change of itself tends to cause the output of the generator to increase. An exploded view of the interior of another form of generator with reversed series field regulation is shown in Fig. 276.

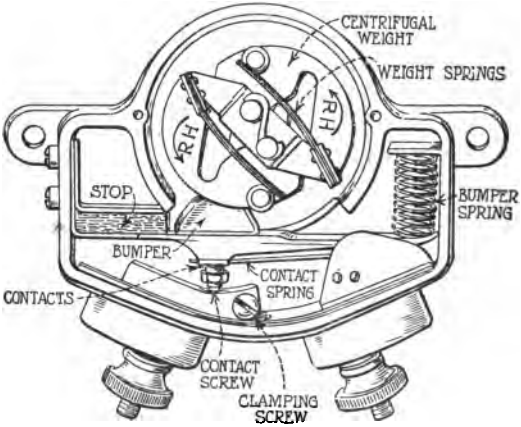


Fig. 278—High-speed position of interrupter weights on Westinghouse combined ignition and lighting generator

In addition to performing the generator functions this machine has a distributer, an interrupter and ignition coil mounted in the end opposite the commutator and thus serves as an ignition unit. A view of the machine with the distributer and interrupter cover removed is shown in Fig. 277, and the position of the interrupter weights at high speed is shown in Fig. 278. A diagram of the connections is shown in Fig. 279.

The operation of the ignition system, including the interrupter and distributer, ignition coil and switch, begins with the making of the primary circuit of the coil when the centrifugal weights push down the fiber bumper, allowing the interrupter contacts to close. Then the weight moves off the fiber bumper, allowing the contacts suddenly to separate or open, when a high voltage is induced in the secondary of the ignition coil and directed by the distributer to the proper spark plug, causing a spark at the spark plug gap. As the speed of the engine increases, the weights are thrown out from the center and automatically advance the time of closing or opening the interrupter contacts and, hence, advance the spark. At the same time, due to their shape, they keep the contacts closed during a greater part of the revolution when running at high speed; this makes the period of contact practically the same at all speeds and prevents the spark voltage from falling off at high speeds.

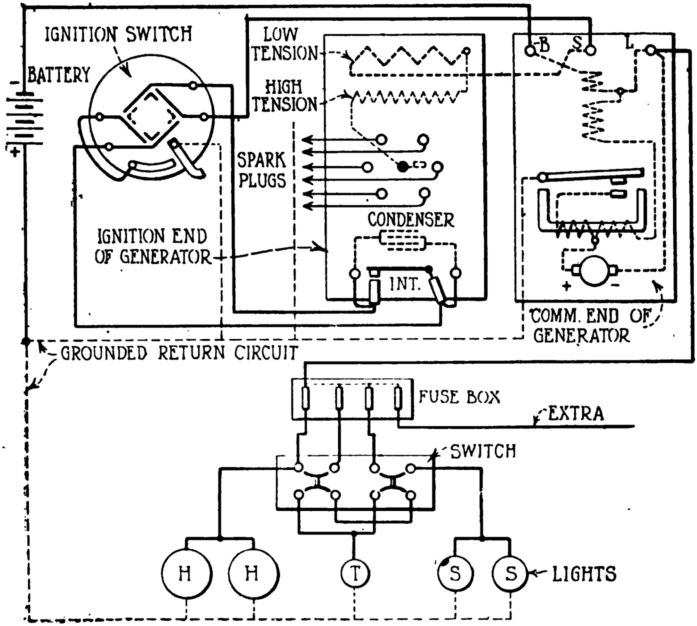


Fig. 279—Internal connections of Westinghouse combined ignition and lighting generator

In generators not provided with automatic spark advance the centrifugal weights are omitted and a cam substituted. The interrupter contacts are changed so as to make the breaking of the contact occur when the lever is pushed down by the cam instead of when being returned by the spring.

The generator with the combined cutout and regulator mounted on it and no ignition head has two terminals marked —B and L or —B and +B, and another machine of exactly the same type but used with an electromagnetic starting motor gearshift has three terminals marked —B, S and L. The generators with the combined cutout and regulator mounted on them and, in addition, an ignition head may have two terminals marked —B and L or —B and +B, or they may have three terminals marked —B, S and L.

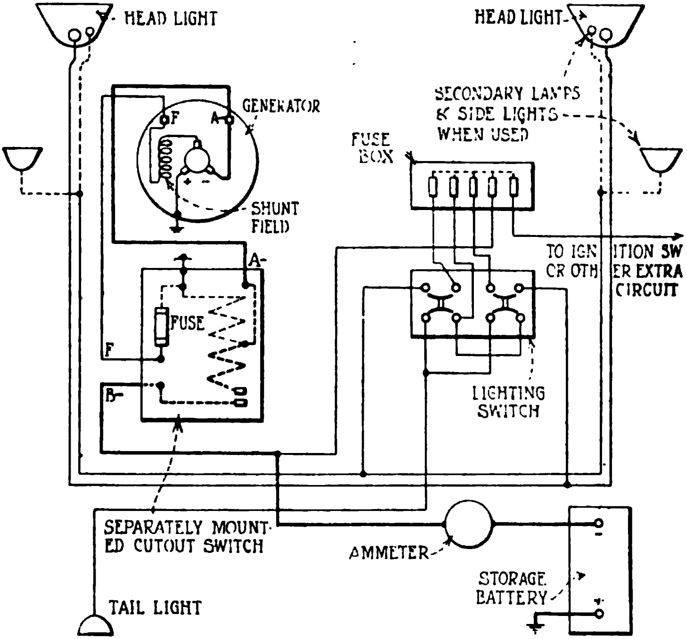

HEAD LIGHT
HEAD LIGHT
GENERATOR
F
A
SHUNT FIELD
SECONDARY LAMPS & SIDE LIGHTS WHEN USED
FUSE BOX
TO IGNITION SW OR OTHER EXTRA CIRCUIT
A-
FUSE
F
B-
LIGHTING SWITCH
SEPARATELY MOUNTED CUTOUT SWITCH
AMMETER
STORAGE BATTERY
TAIL LIGHT

Fig. 280—Wiring diagram of Westinghouse generator with third-brush regulation and separately mounted cutout

Third-Brush Regulation

The generators with third-brush regulation are of the shunt-wound type, and their output is regulated by the third-brush method. An electromagnetic cutout mounted outside the generator automatically connects and disconnects the generator and the battery. In some cases this cutout is combined with the starting switch, and in some cases it is mounted inside the generator frame.

A diagram of a typical system of this kind is shown in Fig. 280. Generators of this type are provided with two terminals marked A — and F, and the cutout has three terminals marked A —, B — and F. An inspection of the diagram will enable you readily to trace the following circuits. The shunt coil and the cutout is connected between the negative terminal of the generator marked A — and the ground which corresponds to the positive terminal of the generator. When the cutout contacts close a circuit is established from the grounded terminal of the generator to the grounded terminal of the battery through the battery, through the ammeter to the terminal B — on the cutout, through the cutout contacts and series coil of the cutout and to the terminal A — on the cutout to terminal A — on the generator, through the generator to

Fig. 281—*Westinghouse lighting generator with vertical ignition head, third-brush regulation* the positive, or grounded, terminal which completes the circuit.

Some of the generators having third-brush regulation have the cutout mounted inside the frame of the machine, and in such cases the generator has only one terminal and this terminal connects to the negative battery terminal. The cutout is mounted inside the cover at the commutator end. The core of this cutout can be raised or lowered and the air gap between the lower end of the core and the movable armature changed. When the adjusting screw is turned to the right the air gap is decreased and the cutout closes at a lower dynamo speed or voltage, while turning the adjusting screw to the left increases the air gap and the cutout closes at a higher dynamo speed or voltage. The frames of

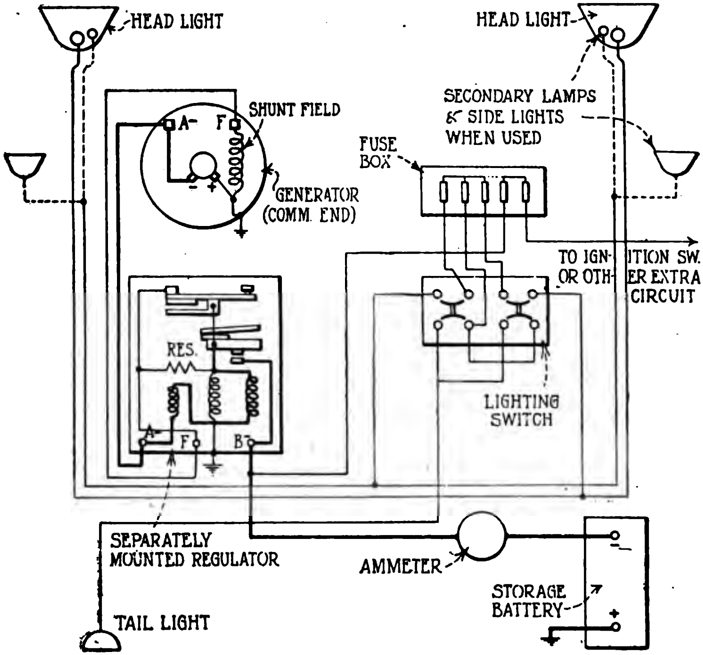


Fig. 282—*Wiring diagram of combined cut-out and voltage regulator, separately mounted* these generators are made from steel pipe and are known as No. 760.

Some of the generators with third-brush regulation are provided with an ignition unit as shown in Fig. 281. Should it be necessary at any time to operate the car with the battery disconnected, the following instructions should be observed properly to protect the system. The 5-ampere fuse in the shunt-field circuit should be removed. This fuse may be mounted on the back of the cutout switch or perhaps inside the switch, in which case there will be a note to that effect on the outside. If no fuse can be found and there is still a shunt-field circuit, any two of the generator brushes should be removed. In removing each brush it should be noticed which side was up, and each brush should be replaced in its original holder with the proper side up, taking care to see that the brush is resting against the commutator.

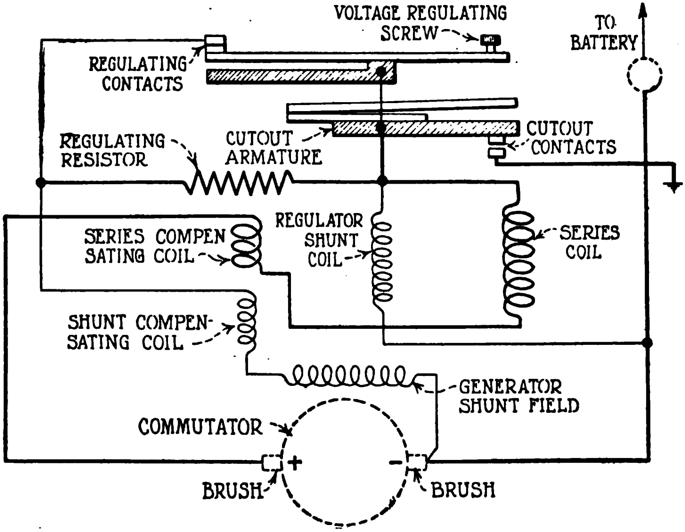


Fig. 283—Wiring diagram of Westinghouse combined cutout and regulator, mounted inside of generator

Electromagnetic Voltage Regulation

Generators with electromagnetic voltage regulation have their output regulated by intermittently varying the resistance of the shunt field circuit. A diagram of the internal connections of a generator of this kind, in which the regulator is mounted separately, is shown in Fig. 282, and one in which the regulator is mounted inside the generator housing is shown in Fig. 283. The principle of operation of the regulator is the same in both cases, and it is combined with the automatic cutout and all placed in one housing. Two views of the combined regulator and cutout are shown in Fig. 284. This combined unit performs the following functions: That of a cutout, which automatically connects and disconnects the generator from the battery when the generator is driven above or below a predetermined speed and that of an automatic voltage regulator which, after the cutout has connected the generator circuit to the battery, automatically keeps the generator voltage at a predetermined value. Each function is performed by its individual element, but the operation of the second function depends upon that of the first.

Fig. 284—*Two views of Westinghouse combined cutout and voltage regulator for separate mounting*

When the generator is being operated at a speed below the predetermined cut-in speed, the contacts of the cutout armature are open, the voltage of the generator being below that of the battery. When the generator speed reaches the cut-in speed these contacts are closed, connecting the generator circuit to the battery circuit. The cut-in speed varies from 5 to 10 m.p.h. on high gear, depending upon the gear ratio and wheel diameter of the particular car.

The cut-in speed of the generator can be observed by running the car, allowing it to increase in speed slowly and observing on the speedometer the speed at which the car is running when the cutout contacts close, which is indicated by a slight movement of the meter needle.

The regulator is so constructed that the cutout operates to disconnect the generator from the battery circuit at a speed slightly below the cut-in speed. This enables the regulator to keep the circuit closed and not constantly open or close it when the car is being run at speeds close to cut-in speed. This disconnecting of the generator from the battery circuit when the generator voltage is below the battery voltage insures that the battery will not be discharged through the generator.

The shunt fields of these generators are so designed that a voltage in excess of the normal voltage regularly would be generated when the generator is operated at high speed and no load. This excess voltage is prevented, and the voltage is held constant by the automatic voltage regulator. When the generator is operating below cut-in speed the contacts of this regulator are closed and remain closed until the generator armature is revolved at a speed which generates a voltage in excess of a predetermined value. This voltage is fixed by the setting of the voltage-regulating screw, which is adjusted at the factory and should be changed only by an experienced man. When, due to the increased speed of the generator, the voltage tends to exceed the value for which the regulator is set, the regulating contacts open, opening the direct shunt-field circuit and cutting in the regulating resistance. This causes a momentary drop in voltage so that the contacts close again. This opening and closing of the contacts is continuous and so rapid as to be imperceptible to the eye and to hold the voltage constant.

The generator used with a separately-mounted combined cutout and regulator has two terminals marked A — and F. The F terminal corresponds to the shunt field, and the A — terminal corresponds to the ungrounded, or negative, terminal of the generator. There are three terminals on the cutout marked A —, F and B —. The A — and F terminals connect to the corresponding terminals on the generator, and the B — terminal connects to the negative terminal of the battery. The generator with the combined cutout and regulator self-contained has only one terminal, and it is marked B —.

Two generators with electromagnetic voltage regulation are equipped with Westinghouse vertical ignition units. These two generators have a self-contained and separately-mounted combined cutout and regulator. The one with the regulator and cutout self-contained has three terminals marked — B, I and S, and the one with a separately-mounted regulator and cutout has three terminals marked — A IG and F.

Mechanical and Electromagnetic Regulation

The frames of the generators, with combined mechanical and electromagnetic regulation, are similar in construction to frame No. 760, having third-brush regulation. The cutout and regulator are carried on the end bracket of the machine next to the commutator. The operation of the cutout is practically the same as that of all electromagnetic cutouts having a shunt and series winding.

The regulator has two movable contacts, and the position of one of these contacts is determined by the magnetic force exerted by a solenoid whose winding is connected across the brushes of the generator, while the position of the second contact is determined by a special cam mounted on the shaft of the generator. This second contact is moved up and down as long as the armature of the generator is rotating. Since the first contact is moved up and down by the variation in the magnetic force acting upon it and since this magnetic force depends upon the current in the solenoid, which varies directly as the voltage between the brushes of the generator, it is evident that the duration of the time that the two contacts are in actual contact will depend upon the voltage of the generator.

If the lower contact has not reached the limit of its upward travel when it touches the upper contact, it merely pushes the upper contact upward until it reaches the limit of its upward travel. Hence, the nearer the upper contact point is to the lower contact point, when the lower contact point is in its lowest position, the longer the total time the contact points are in actual contact as the cam revolves. On the other hand, if the upper contact be raised, the time the two are in contact as the cam revolves will be decreased.

While the contact points are touching each other the field current passes directly between them, but when the points are separated the field current must pass through a resistance connecting the contact points and thus decreasing the field current and hence the voltage of the generator. The frames of these machines are designated as No. 761 R.

Generator and Starting Motor Unit

In the combined generator and starting motor unit the generator and starting motor actions are combined, and the voltage of the system is 12 volts with the positive side grounded. The internal connections of a system of this kind are shown in Fig. 285, and the operation of the system easily may be followed by reference to this figure. The generator is provided with two field windings, one of rather large wire and comparatively few turns and the other one of small wire and a relatively large number of turns. When the starting switch is closed a circuit is completed through the series winding of the machine and its armature, and it operates as a series motor. The regulation of the output of the machine as a generator is by the third-brush method, in combination with the reversed series field.

In some systems using this type of generator the starting and ignition switches are combined and no automatic cutout is used, the combined switch remaining closed as long as the engine is in operation. A system of this kind is shown in Fig. 285, and the electrical unit has two terminals. Other systems using the combined generator and motor unit have an automatic cutout mounted separate from the generator, and in such systems the starting switch and cutout are combined. The generator has only one terminal.

Westinghouse Starting Motors

The electrical operation of the numerous Westinghouse starting motors is practically the same. They are of the series type, and their chief difference is in the mechanical construction of their frames so as to suit them to the different methods of mounting the motors on the engines and the different method of transmitting power from the motor shaft to the engine crankshaft. Two general systems are employed by Westinghouse for connecting the starting motor to the engine crankshaft. In one the engine is driven by a gear, in the majority of cases on the flywheel, that has a sliding pinion meshing with it, which in turn is driven directly or through a reduction gearing by the starting motor and is brought into and out of mesh with the gear on the flywheel by a special shifting lever or some automatic device. In the second system the reduction gears are mounted in the motor housing, and the slow-speed intermediate shaft is connected to the engine crankshaft by an overrunning clutch which prevents the starting motor from being run by the engine.

The intermediate gears connecting the motor to the engine may be brought into mesh by pressing a starting pedal, and after the pedal has moved far enough to throw the gears into mesh the starting switch is closed by a further movement of the starting pedal. Another system makes use of a powerful solenoid in shifting the gears. In this system three switches are used. A push button on the dash is marked start, another switch is mounted in a cylindrical housing through which the starting cable runs and to which there is a wire from the switch on the dash, and the third is the main starting switch connected to the shifting pinion. Closing the push-button switch on the dash sends current through the solenoid operating the cylindrical switch and causes this switch to close, and the circuit is completed to the large starting switch through a powerful solenoid and to ground. This solenoid pulls on a plunger attached to the sliding gear and main starting switch contacts and connects the motor to the engine and closes the starting motor circuit. The electrical connections are such that when the voltage of the generator is equal to the voltage of the battery there will be no current flowing through the switch windings, which was closed by the dash switch, and this will result in the main starting circuit being opened no matter whether the push-button switch on the dash is opened or remains closed.

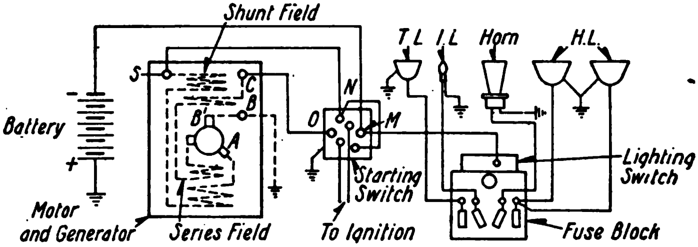


Fig. 285—*Wiring of Westinghouse combined generator and motor unit*

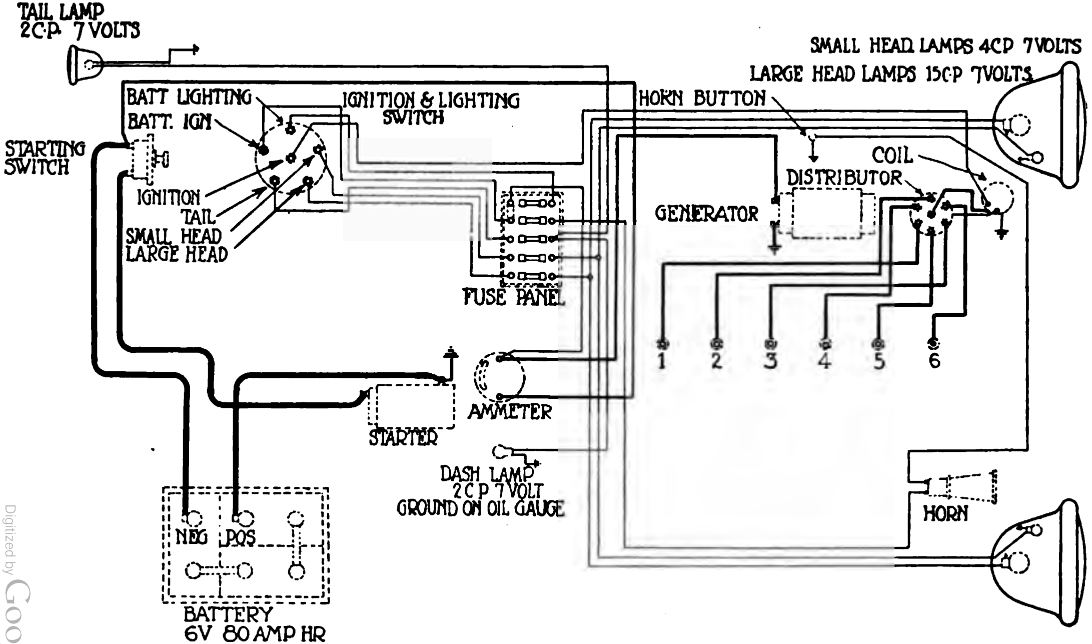


Fig. 286—Wiring diagram of Westinghouse installation on 1917 Chalmers 35A and 35B

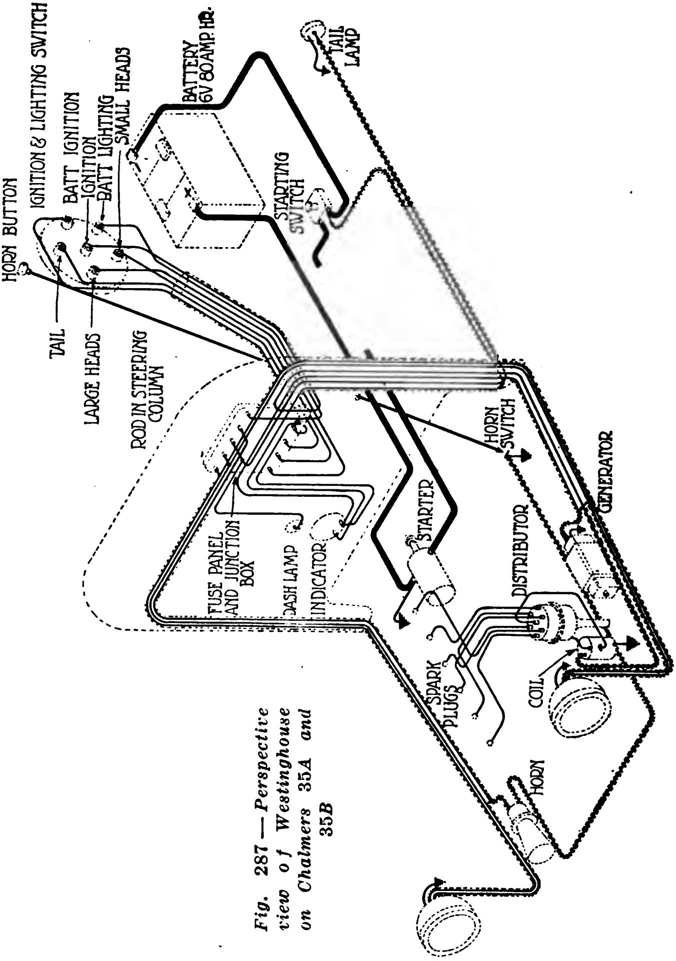


Fig. 287 — *Perspective view of Westinghouse on Chalmers 35A and 35B*

A third type of pinion, or gearshift, operates as follows: Closing the main electrically-operated switch starts the motor, and it runs at slow speed and then the circuit of the magnetic pinion shift is closed. The operation of the pinion shift disconnects the motor for a brief period, and it revolves due to its own momentum until the gears mesh and then full voltage is applied to the motor. When the starting push-button is released all the various gears and switches are restored to their original condition. In these installations the electrical connections are such that as soon as the engine runs at a speed sufficient to cause the voltage in the generator to be equal to the voltage of the battery, the electrically operated switch opens, even if the driver fails to release the starting-switch button.

A fourth type of automatic screw pinion shift, known as the Bendix drive, is employed. The starting switch may be closed by a foot pedal, or it may be operated electrically by an electromagnet and the circuit of the electromagnet opened and closed by a push-button switch. A fifth and comparatively new method of gear connection between the motor and the engine is one in which the starting motor is connected by gears to the transmission countershaft in place of the engine flywheel or crankshaft. Two spur reduction gears are mounted on a countershaft in such a way that one may be made to mesh with a pinion on the armature shaft of the starting motor, and at the same time the other may be made to mesh with one of the transmission gears. These intermediate gears, together with the shaft upon which they are mounted, are moved back and forth by the starting lever. The electrical circuit through the armature and field windings of the starting motor is closed by the action of the starting lever after it has moved a sufficient amount to cause the gear to be in mesh. No overrunning clutch is required, as the transmission gears when operating under the action of the engine throw the reduction gears out of mesh.

Installation on 1917 Chalmers

Two wiring diagrams of a typical Westinghouse installation are given in Figs. 286 and 287. This is a three-unit, single-wire, 6-volt installation with the positive side of the system grounded. The starting motor circuit may be traced as follows: Starting with the positive side of the battery along the large cable to the grounded terminal of the starting motor, through the starting motor to the starting switch, through the starting switch, when its contacts are closed, to the negative terminal of the battery.

The automatic cutout is located in the generator housing, and the charging circuit may be traced as follows, assuming the cut-

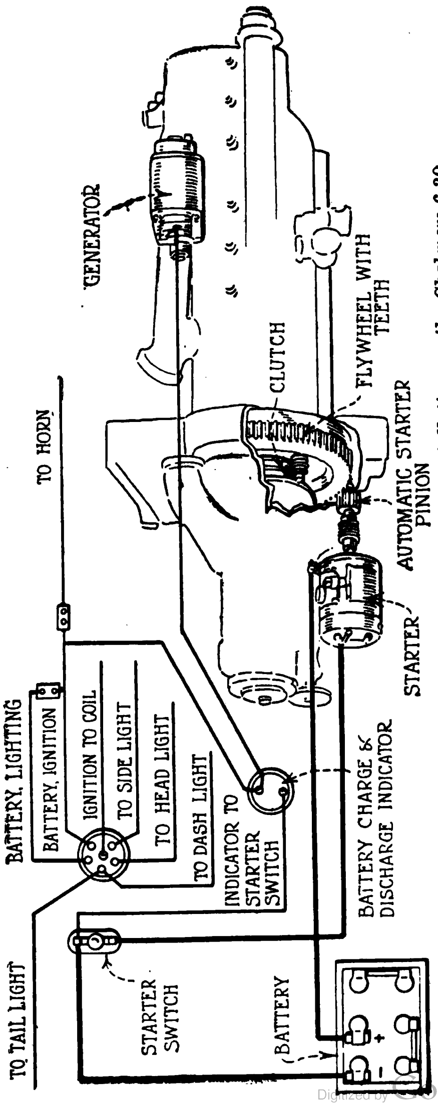


Fig. 288—*Diagrammatic view of Westinghouse installation on the Chalmers 6-30* out is closed: From the negative terminal of the generator through the contacts of the cutout to the ungrounded side of the generator from the ungrounded, or negative, terminal of the generator to one side of the battery indicator, through the indicator to one side of the starting switch, thence to the negative side of the battery along the heavy cable. The positive side of the generator and battery are both grounded; hence, they are connected together permanently and the circuit is complete. If any current is being taken by any one of the various lamp circuits, the current passing through the indicator will be equal to the current delivered by the generator less the current taken by the lamps, ignition apparatus, etc. When the current taken by the lamps, ignition, etc., exceeds in value the current delivered by the generator then the battery discharges and assists the generator and the indicator shows a discharge rather than a charge.

Two bulbs are provided in each head lamp, and the circuit through these bulbs is completed through the ground or frame of the car. The dash and tail lamps are each 7-volt bulbs, and they are connected in parallel and controlled by the same switch. A diagrammatic view of this installation is shown in Fig. 288.

CHAPTER XXVIII

Gray & Davis Electrical Systems

THE various Gray & Davis electrical systems for the motor car may be conveniently grouped into two main classes, depending upon the kind of generator that is used, namely, constant-speed generator systems and variable-speed generator systems.

Constant-Speed Generator Systems

The generators used in the constant-speed generator systems are of the constant-speed type. The generator is driven by the engine through a specially-constructed friction governor which prevents the speed of the armature of the generator from exceeding a predetermined value regardless of the speed of the engine. These generators are either two- or four-pole depending upon the type. They all have round frames and may be used with single or two-wire systems. They are compound-wound and they

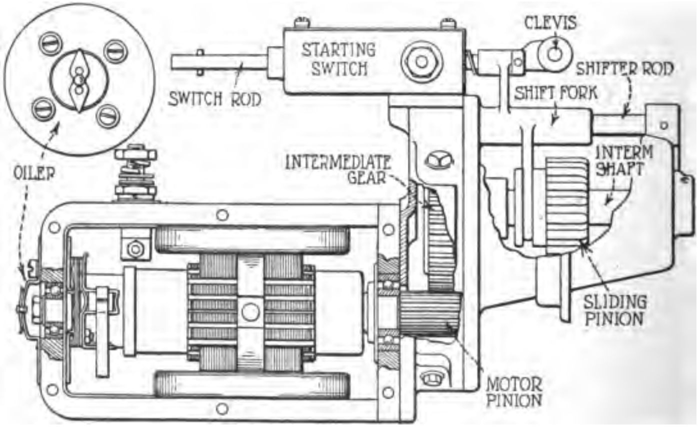


Fig. 289—*Sectional view of Gray & Davis starting motor, type Y*

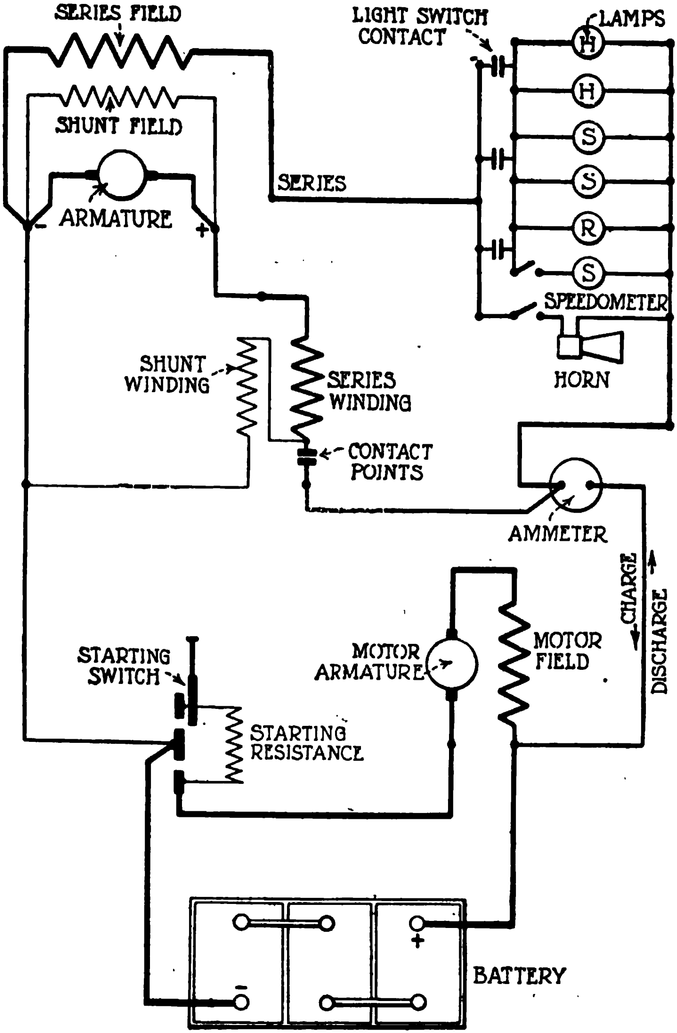


Fig. 290—Wiring diagram of Gray & Davis two-wire installation, constant-speed compound-wound generator

operate as simple shunt machines except when the lamps are turned on. The current taken by the lamps passes through the series field and increases the output of the generator as the demand is increased.

An electromagnetic cutout is provided in the circuit between the generator and the battery and closes and opens the circuit when the voltage is above or below the voltage of the battery.

The starting motors are of the two-pole type and are connected to the engine by a gear reduction to a jackshaft upon which there is a sliding pinion which meshes with a gear on the flywheel rim. The sliding pinion is provided with an overrunning clutch. The starting switch and sliding pinion are operated by means of the same pedal or lever, as shown in Fig. 289.

Another type of a connection between the starting motor and the engine is made by a silent chain running over a sprocket on the engine crankshaft and a double sprocket on the shaft of the starting motor. A set of reduction gears is carried inside the motor housing and an overrunning clutch is built inside the motor sprocket.

The wiring diagram of a two-wire system is shown in Fig. 290, and a plan view of the installation is shown in Fig. 291. The starting switch is so constructed that a resistance is connected in series with the battery and starting motor when the switch is in the first position, and this resistance is cut out of circuit when the switch is completely closed.

Variable-Speed Generator Systems

The generators used in the variable-speed generator systems are connected mechanically to the engine and always run at a definite speed in relation to the engine speed. The machines are shunt-wound, and their output is regulated by either the third-brush, or electromagnetic method, depending on the model.

Electromagnetic Regulation

The generator with electromagnetic regulation is a rectangular frame machine and the combined cutout and regulator is mounted in a rectangular housing on top of the generator. Looking down on the regulator, there are six terminals visible, three at each end. The two outside terminals on the driving end are marked B and L respectively. The terminal marked L is connected to

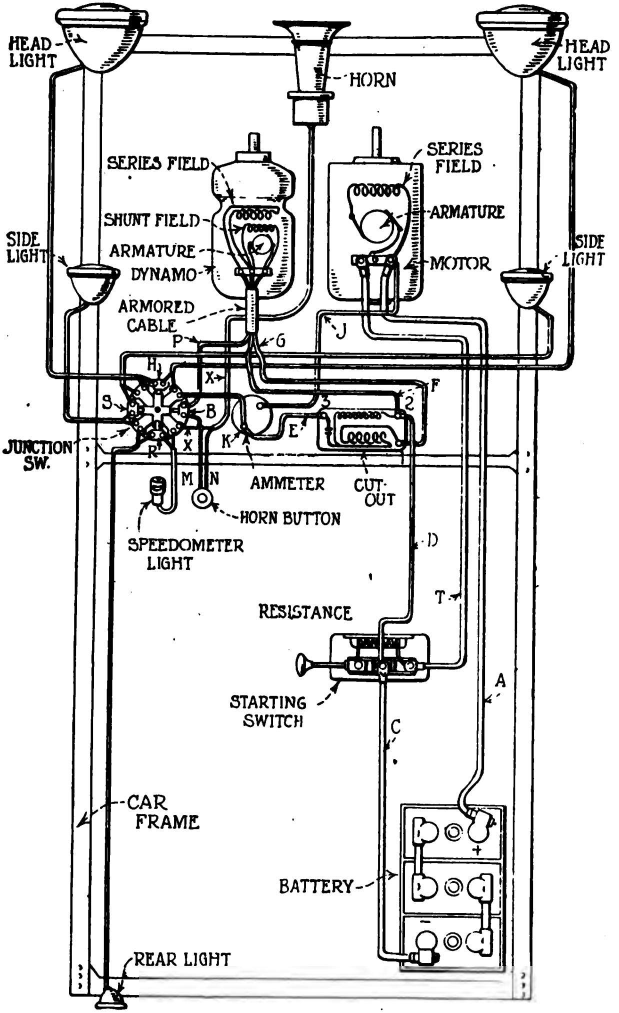


***Fig. 291**—Plan view of typical Gray & Davis two-wire installation, constant-speed constant-wound generator*

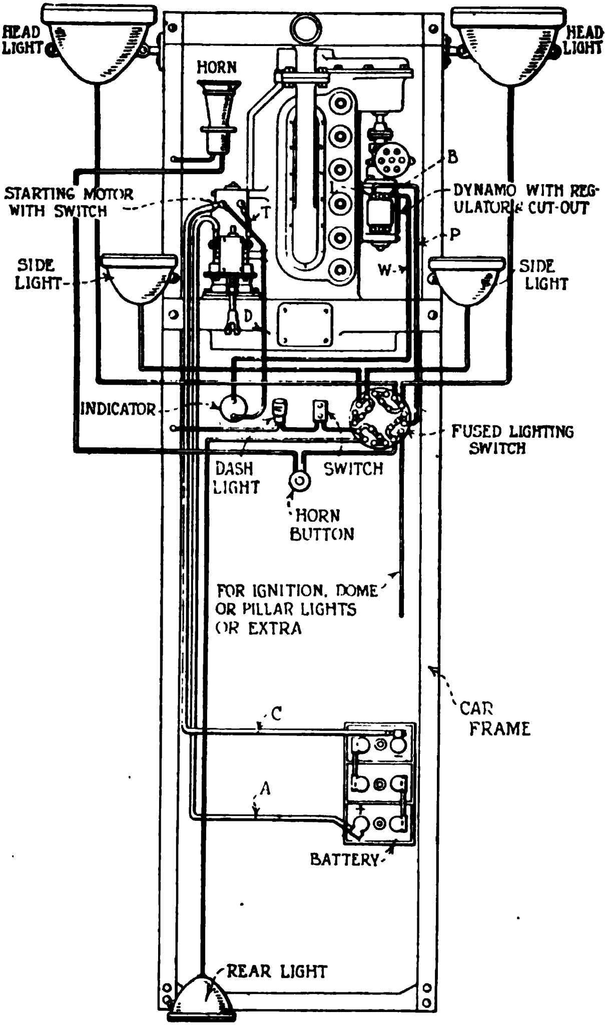


Fig. 292—Plan view of typical Gray & Davis single-wire system, variable-speed shunt-wound generator

the lighting switch, and the terminal marked B is connected to the negative terminal of the battery with a current indicator in series. These connections are all plainly shown in Figs. 292 and 293. The center terminal at the drive end of the generator is unmarked and is used in grounding one end of the shunt coil on the combined cutout and regulator. The three terminals opposite the drive end are marked A, F and F-1 respectively and are used in making the connections between the combined cutout and regulator and the armature and field of the generator. No external connections are made to these terminals.

The internal connections of the combined regulator and cutout are shown in the wiring diagram in Fig. 293. The regulator has two sets of contacts, and each set when closed short-circuits a resistance in the field circuit. With an increase in output there is an increase in the magnetic pull on the armature controlling these points, and finally they are opened and the field resistance increased, which lowers the field current and thus decreases the output. This opening and closing of the regulator contacts is very rapid after the output of the generator has reached the value for which the regulator is adjusted. The current taken by the lamps does not pass through all the series turns of the combined regulator and cutout, and as a result when the lamps are turned on the output of the generator is increased. Fuses are provided in the circuits to the lights and horn as shown in Fig. 293. These fuses all are mounted on the back of the lighting switch. The lighting switch is of the rotary type and has four positions as follows: First, side and tail lamps; second, head and tail lamps; third, all lamps on; and fourth, all lamps off.

The starting motor used with this type of generator is of the series-wound type and is connected mechanically to the engine either by a pinion which meshes with a gear on the flywheel or by a silent chain and overrunning clutch.

Third-Brush Regulation

The generator with third-brush regulation is a rectangular-frame, two-pole, shunt-wound machine. The electromagnetic cutout is located inside the generator frame above the commutator. There is only one terminal on the machine, and this connects with the negative terminal of the battery.

The motor used with this system is a rectangular-frame, two-

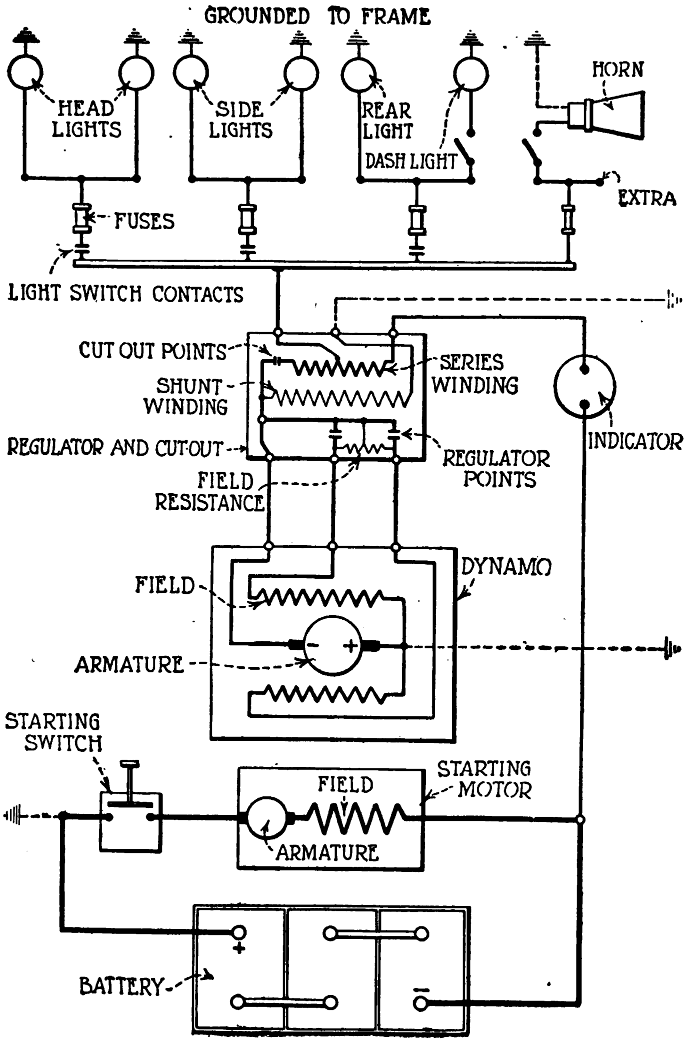


Fig. 293—Wiring diagram of Gray & Davis single-wire installation, variable-speed shunt-wound generator

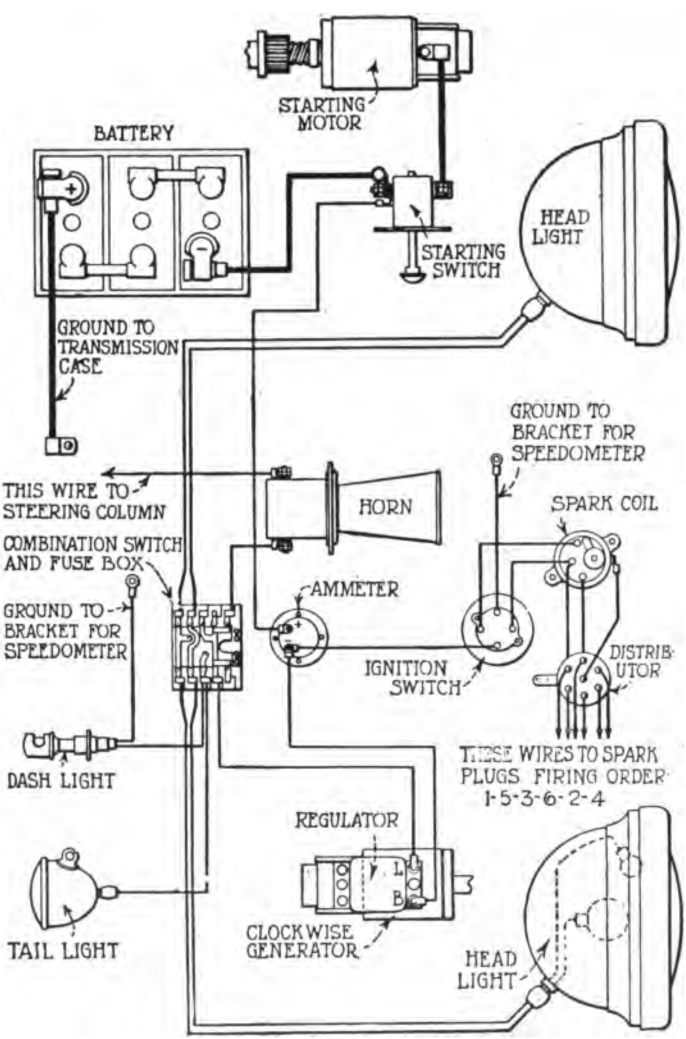

STARTING MOTOR
BATTERY
+
−
HEAD LIGHT
STARTING SWITCH
GROUND TO TRANSMISSION CASE
GROUND TO BRACKET FOR SPEEDOMETER
THIS WIRE TO STEERING COLUMN
HORN
SPARK COIL
COMBINATION SWITCH AND FUSE BOX
AMMETER
GROUND TO BRACKET FOR SPEEDOMETER
DISTRIBUTOR
IGNITION SWITCH
DASH LIGHT
THESE WIRES TO SPARK PLUGS FIRING ORDER 1-5-3-6-2-4
REGULATOR
L
B
TAIL LIGHT
CLOCKWISE GENERATOR
HEAD LIGHT

Fig. 294—Wiring diagram of Gray & Davis installation on the Paige H2-6-38

pole, series-wound machine and has only one terminal, which connects to the starting switch and from there to the negative terminal of the battery.

The Gray & Davis generators are described quite completely in the section devoted to the Gray & Davis system for Ford cars.

A complete wiring diagram of the Gray & Davis installation on the Paige is shown in Fig. 294. It is a three-unit, 6-volt, single-wire system. The output of the generator is regulated by the electromagnetic method. The combined cutout and regulator are in a rectangular housing on top of the generator.

The starting motor is a two-pole series-wound machine, and an automatic pinion is used in connecting it to the engine.

A battery ignition system made by the Remy Electric Co. is used, and current is supplied either by the storage battery or the charging generator.

CHAPTER XXIX

USL Electrical Systems

GENERATOR and starting motor actions are combined in a single-unit in all the different electrical systems for the motor car as manufactured by the U. S. Light & Heating Corp. The field structure of the unit is stationary, and the armature is fastened to the crankshaft of the engine in place of the flywheel. In some systems the armature rotates outside the field structure, while in the other systems the armature rotates inside the field as in ordinary practice.

Four principal types of equipment are supplied by the USL company, and these different types differ from each other chiefly in the method employed in regulating the output of the unit as a generator and the different combinations of voltages used in starting and charging.

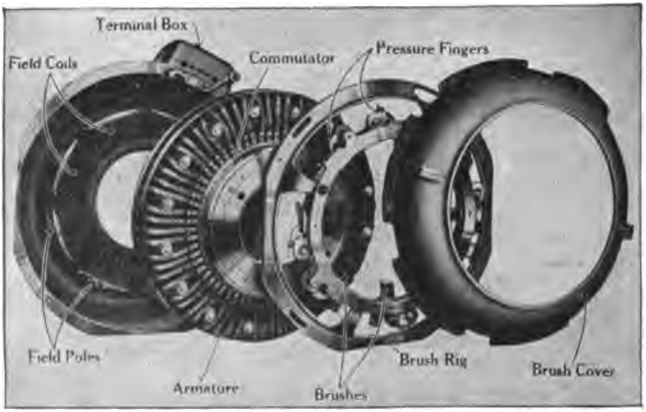


Fig. 295—*USL* 24-12 *volt system, external regulator and external armature type*

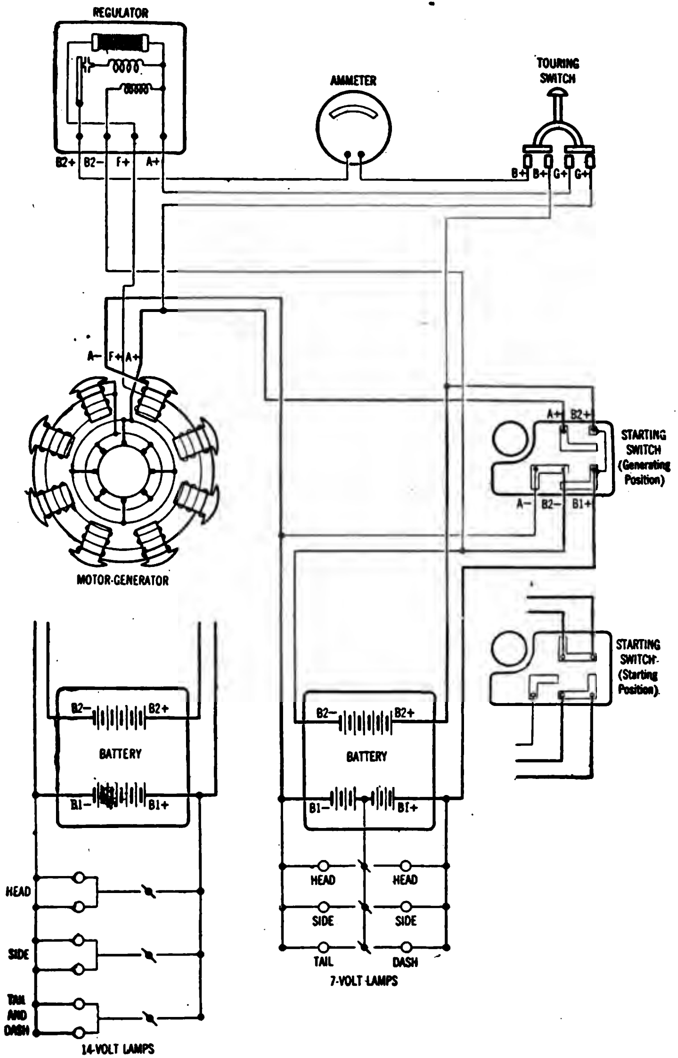


Fig. 296—*Wiring diagram of the USL 24-12 volt system, external regulator and external armature type*

An exploded view of the electrical unit for the 24-12-volt system is shown in Fig. 295, and a typical wiring diagram is given in Fig. 296. The battery used with this system consists of twelve cells divided into two groups of six cells each. These two groups are connected in series by the special rotary drum starting switch when the electrical unit operates as a starting motor and in parallel when the electrical unit is operating as a generator. In some installations the lights are operated direct from the two groups of cells in parallel or from a single group when the starting switch is depressed and they are of the 14-volt type. Some installations make use of a three-wire system for lighting, and in such cases the lamps are of the 7-volt type. Both of these systems of wiring are shown in the lower left-hand corner in Fig. 296.

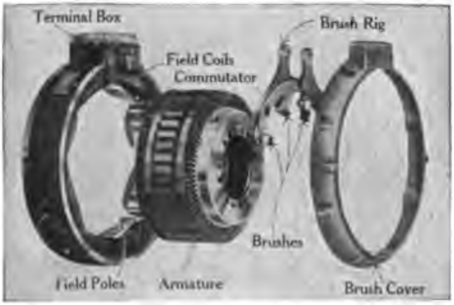


Fig. 297—USL 12-6 volt system, external regulator and internal armature type

The electrical unit is an eight-pole machine, and the fields are compound-wound. Both windings are used for generator and motor actions. The internal connections are plainly shown in Fig. 296. There are three terminals on top of the flywheel case.

A diagram of the combined cutout and regulator is shown in the upper left-hand corner of Fig. 296. Both the cutout and regulator functions are taken care of by a single electromagnet, which has a shunt and series winding. The cutout contacts close and open the circuit connecting the generator and the battery in the usual manner. The regulator acts to vary the pressure on

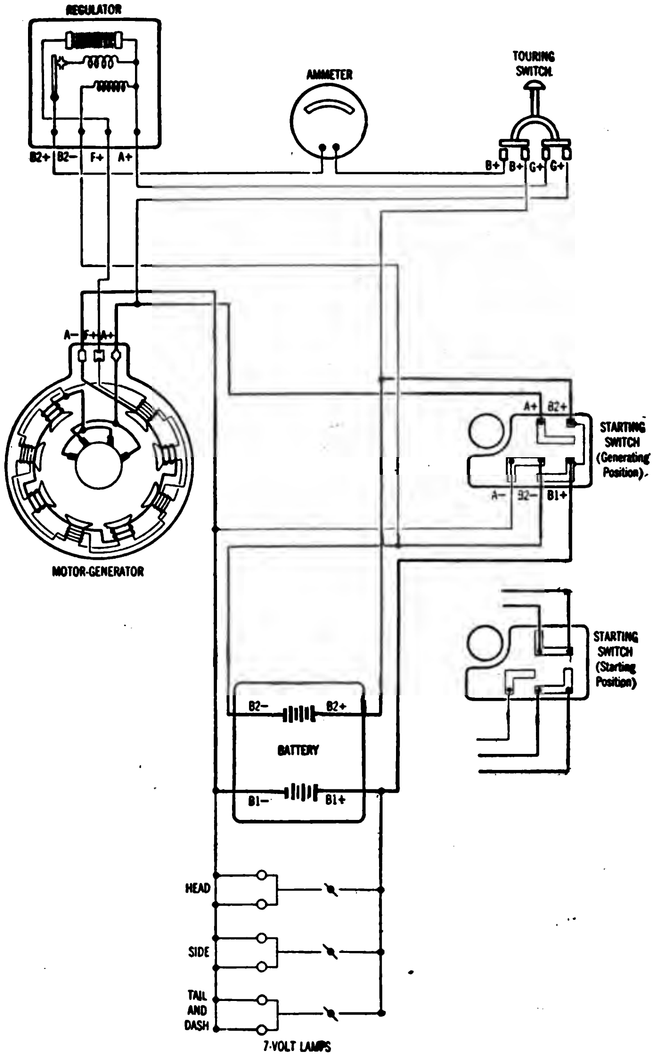


Fig. 298—Wiring diagram of the USL 12-6 volt system, external regulator and internal armature type

a small carbon resistance connected in series with the shunt field winding and thus varies the shunt excitation as the output changes. The magnetizing action of the series field winding opposes the magnetizing action of the shunt field winding when the unit is acting as a generator and thus tends to prevent an excessive increase in the output of the machine.

The two positions of the starting switch are clearly shown in Fig. 296, and the starting motor and generator circuits easily may be traced by reference to this figure.

The touring switch shown in the upper right-hand corner of Fig. 296 enables the driver to control the charging of the battery. With this switch open the generator will not charge the battery, while with this switch closed the generator will charge the battery, provided the engine speed is sufficient.

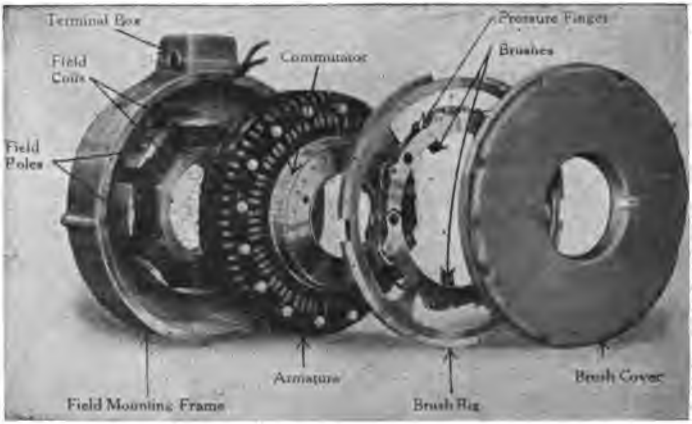


Fig. 299—*USL* 24-12 *volt system, inherently regulated and external armature type*

12-6 Volt System, External Regulator

An exploded view of the electrical unit for the 12-6 volt system is shown in Fig. 297, and a typical wiring diagram is given in Fig. 298. The battery used with this system consists of six cells divided into two groups of three cells each. These two

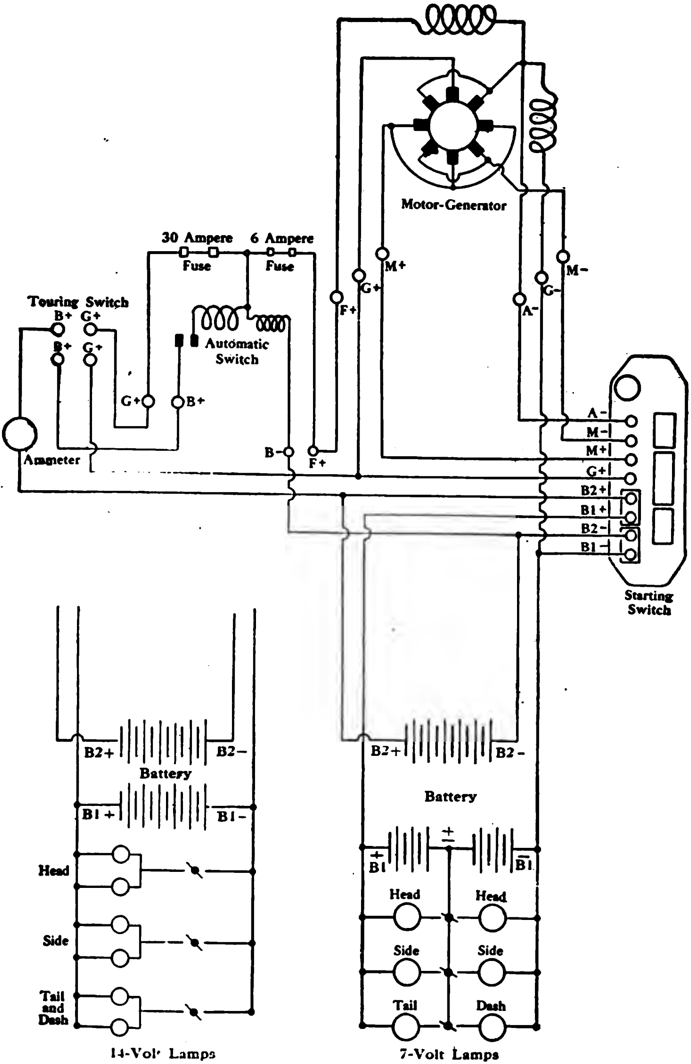


Fig. 300—*Wiring diagram of the USL 24-12 volt system, inherently regulated type*

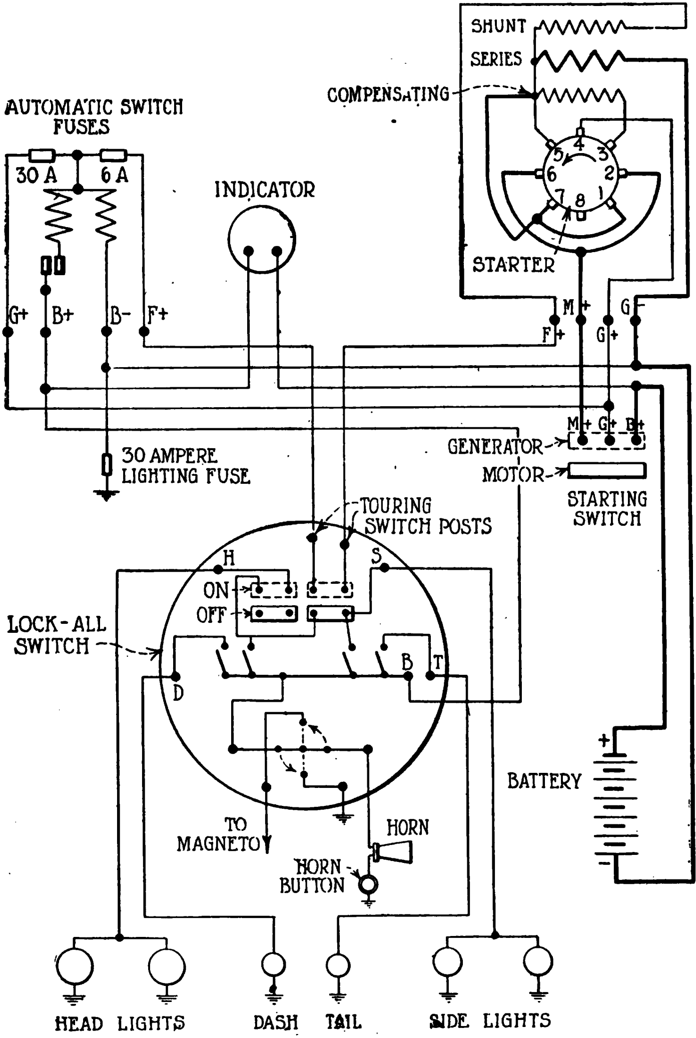


Fig. 301—*Wiring diagram of the USL* 12-12 *volt system, inherently regulated type*

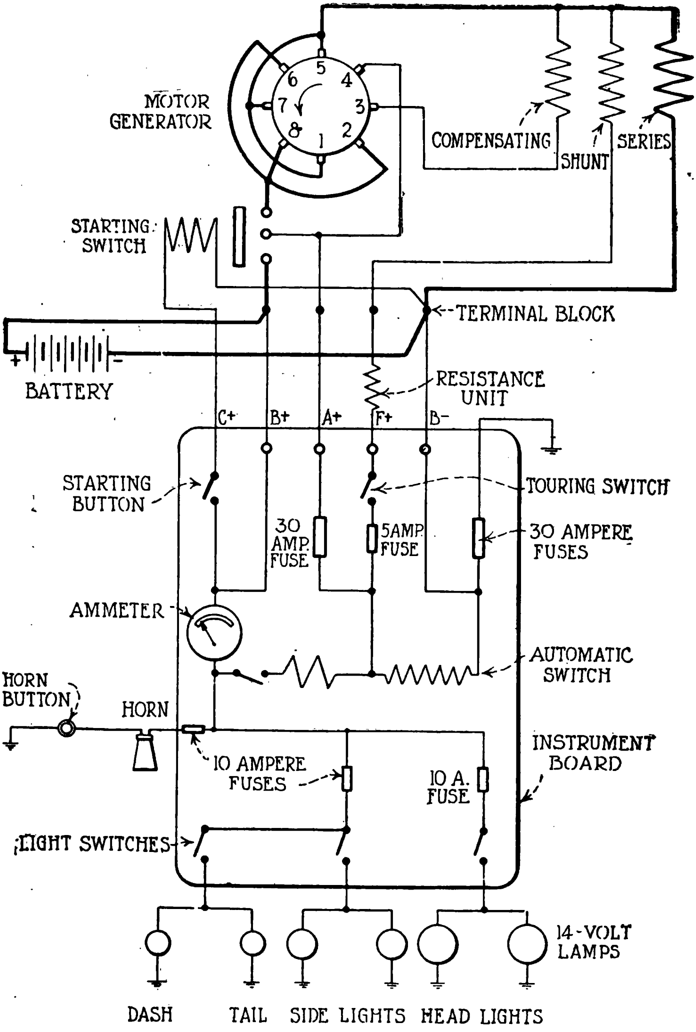


Fig. 302—*Wiring diagram of the USL installation on the* 1916 *Mercer* groups are connected in series by the special rotary drum starting switch when the electrical unit operates as a starting motor and in parallel when the electrical unit is operating as a generator. The lights are operated direct from one section of the battery, and they are of the 7-volt type.

Alternate poles of the electrical unit have a shunt winding, and the remaining poles have a series winding. The operation of the cutout, regulator, starting switch and touring switch all are the same as for the system described in the previous section.

24-12 Volt System, Inherently Regulated

An exploded view of the electrical unit for this system is shown in Fig. 299 and a typical wiring diagram is given in Fig. 300. The battery used with this system consists of twelve cells divided into two groups of six cells each. These two groups are connected in series by the special starting switch when the electrical unit operates as a starting motor and in parallel when the electrical unit is operating as a generator. The lights are operated on either the two- or three-wire plan, as shown diagrammatically in Fig. 300.

Seven of the eight poles of the electrical unit have a series winding on them, and the remaining pole is provided with a shunt winding. The poles on the opposite sides of the pole having the shunt winding on it are of the same polarity as the shunt pole. The demagnetizing effect of these poles upon the shunt pole acts to prevent the output of the generator from becoming excessive.

The cutout is of the electromagnetic type and is carried on the engine side of the dash. Two fuses are mounted on the cutout base, one, of 6-ampere capacity, in the shunt field circuit and the other, of 30-ampere capacity, in the main circuit of the electrical unit. A touring switch is provided, and its operation will be obvious after an inspection of the wiring diagram. An indicating ammeter is mounted on the dash and is connected in the circuit from the positive terminal of the battery to the touring switch.

12-12 Volt System, Inherently Regulated

A typical wiring diagram of a 12-12-volt system is given in Fig. 301. The electrical unit has four terminals, the automatic cutout has four and the starting switch has three. The three terminals of the starting switch are connected together when the starting switch is in its closed position, and no connections are made through the starting switch when the electrical unit is operating as a generator. The touring, ignition and lighting switches all are combined in a single unit.

A compensating field coil is used in addition to the shunt and series field coils described. This compensating field coil is connected to brush No. 3, as shown in the diagram. The object of this compensating coil is to weaken the magnetic field with an increase in speed, but this effect is not very noticeable until the generator has practically reached its maximum output.

A wiring diagram of the USL installation on the 1916 Mercer is shown in Fig. 302. This is a two-unit, 12-volt, two-wire system. The generator has inherent regulation due to the combined actions of a series and compensating field winding. The starting switch is operated magnetically by closing the starting button on the dash.

On the 1917 Mercer cars a magnetic switch is used to open and close the shunt-field circuit. This switch closes and connects the shunt field directly to the battery unless the touring switch is open. Supplying current direct from the battery to the shunt field winding causes the electrical unit to pick up quickly.

CHAPTER XXX

Leece-Neville Electrical Systems

THE generator for the 1913 Leece-Neville systems is bipolar, and for the 1914 systems it is multipolar. It is connected to the engine by gears and delivers current to the storage battery at a pressure of 12 volts. The circuit between the generator and battery is closed and opened by a special two-pole cutout, which also serves as a visual battery indicator as to whether the battery is being charged or not. The output of some of the generators is regulated by armature reaction. They are shunt-wound machines, and a maximum current of approximately 12 amperes is reached at a speed of about 15 m.p.h. In some cases the generators are provided with both a shunt and series field winding, and in each case the magnetizing action of the series field opposes that of the shunt field and thus tends to prevent an excessive rise in the output of the generator as the speed increases.

The starting motors used in 1913 were bipolar, and those used in 1914 were multipolar. The motors are connected to the engine through reducing gears arranged to mesh with gears on the flywheel of the engine. The starting switch has four terminals and may be of the rotating-drum or sliding-contact type. The same rod that throws the motor gears into mesh transmits the necessary motion to the starting switch. The rod itself on some cars is operated by moving the transmission gearshift lever into a special slot and then pushing it forward quickly to the end of the slot. A spring throws the gears out of mesh when the lever is returned to its neutral position and the starting switch is opened. On cars equipped with magnetic gearshifts, the rod which operates the intermediate gears and the starting switch itself is operated by the starting pedal. Pressing a button on the dash marked ''start'' connects the rod to the clutch pedal magnetically, and the gears are thrown into mesh and the starting switch closed by throwing the clutch pedal forward. When the button on the dash is released the gears are thrown out of mesh by a spring and the starting switch is opened.

In the 1913 installations the reduction gears are not incased, while in the 1914 installations the gears are incased in the end yoke of the motor, which makes it possible to keep them well greased.

The wiring of the car is such that the lamps operate on 6 rather than 12 volts. A wiring diagram of the Leece-Neville installations is shown in Fig. 303.

The output of the 6-volt generators for 1915, 1916, 1917 and 1918 is regulated by the third-brush method. They are shunt-wound, and a coil is placed on each of the four poles. In some cases an ignition head is mounted on the generator. Some of the systems make use of a four-terminal two-pole electromagnetic cutout mounted on the dash, while other systems have the cutout mounted on the generator.

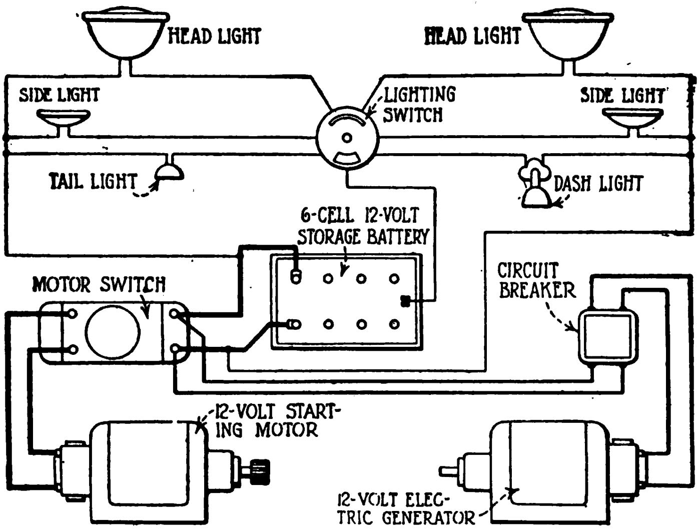


Fig. 303—Wiring diagram of the Leece-Neville installation on **1913** *and* **1914** *cars*

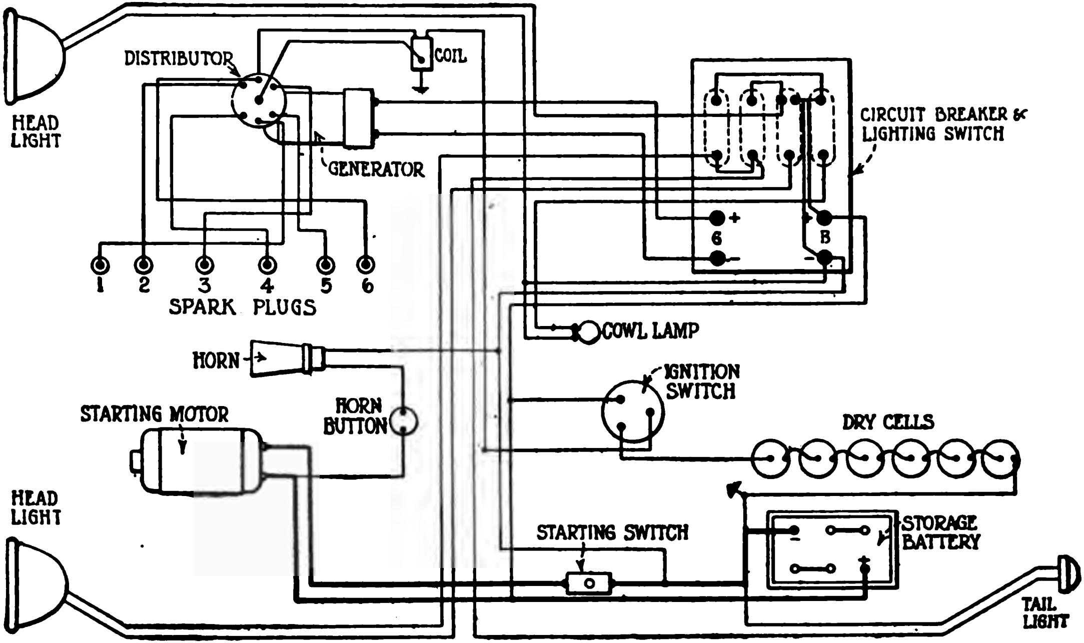


Fig. 304—Wiring diagram for Leece-Neville starting, lighting and ignition on 1915 Haynes light six

The starting motors are four-pole, series-wound. In some installations the motor is connected to the engine by a planetary reduction gearing mounted in the end of the motor frame and a silent chain which drives through an overrunning clutch. Other installations make use of the Bendix drive in connecting the motor to the engine crankshaft.

The starting switch may be of the two-terminal plunger type mounted under the floorboard, or it may be mounted on top of the starting motor and operated by a rod.

Installation on 1915 Haynes

The installation on the 1915 Haynes is a 6-volt, two-unit, two-wire system. A wire diagram of the system is shown in Fig. 304. The output of the generator is regulated by the third-brush method. Rotating the third brush in the direction of rotation increases the current output of the generator at any given speed, while moving the third brush in the opposite direction to the rotation of the armature decreases the output. The generator and storage battery are connected and disconnected by a two-pole cutout which opens both sides of the circuit. No ammeter is used, but a target is mounted on the cutout in such a way that the word "Off" appears through an opening in the front of the instru-

Fig.* 305—*Leece-Neville cowl panel on* 1915 *Haynes light six

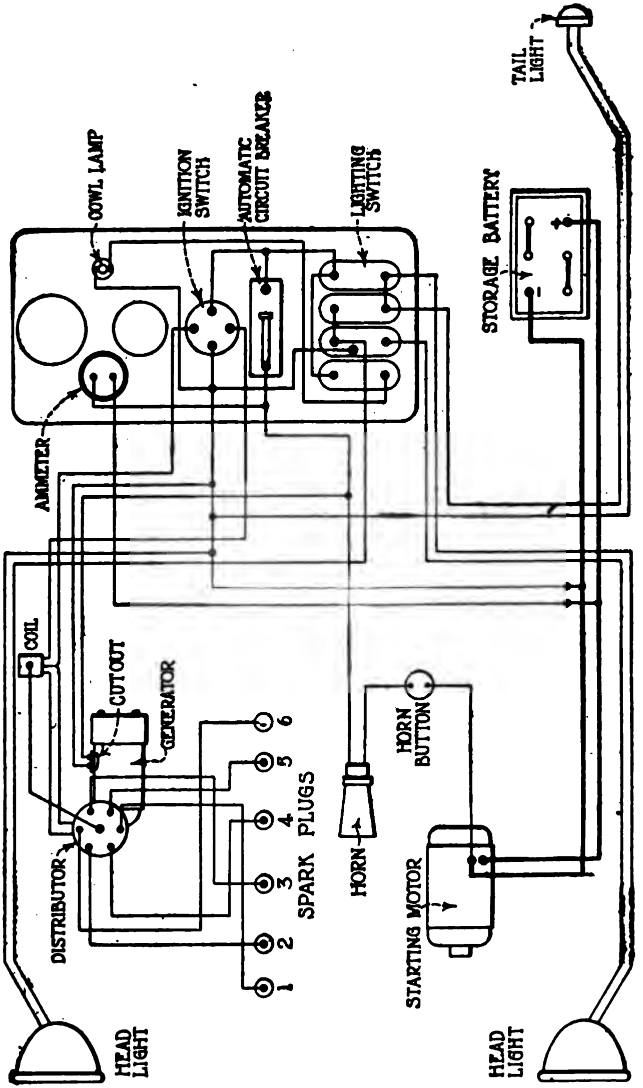


Fig. 306—Leece-Neville installation on the 1917 Haynes light six

ment when the generator is not charging the battery and the word "Charging" appears when the battery is being charged. This combined indicator and target is mounted on the dash of the car together with the light switches, and a front view of the panel is shown in Fig. 305. Three lighting buttons are provided, and they operate the following circuits: The upper one when it is pulled out turns on the head lights dim with the tail light bright; when the second switch is pulled out, leaving the upper one out, the head lights are turned on bright and the tail light remains bright; the third switch controls the cowl light.

There are two running positions for the ignition switch, so that current for the ignition system may be drawn from either of two sources, the storage battery or a battery of six dry cells. The negative side of the primary winding of this ignition circuit is grounded.

Installation on 1917 Haynes

The installation on a 1917 Haynes is a 6-volt, three-unit, two-wire installation. A circuit diagram of the system is shown in

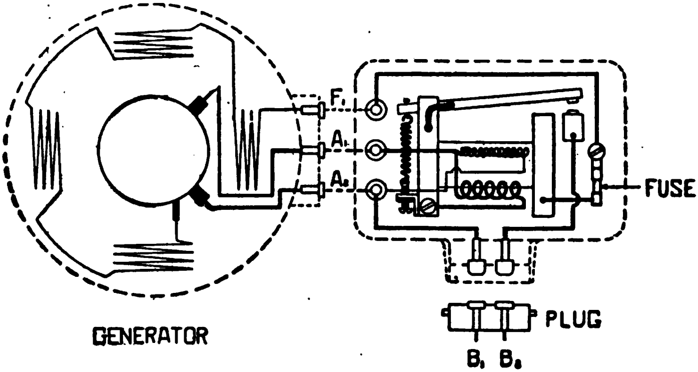


Fig. 307—Wiring diagram of Leece-Neville generator and circuit breaker on 1917 Haynes light six

Fig. 306. The generator and motor are both of the round frame, four-pole type. The output of the generator is regulated by the third-brush method, and it automatically is connected to and disconnected from the battery by an electromagnetic cutout. This

cutout is mounted on top of the generator, and connections are made to it by a plug, as shown diagrammatically in Fig. 307. The fuse in the shunt field circuit serve as a protection to the generator should the cutout contacts fail to close or the generator be operated, with the battery removed. It is best always to remove this fuse when the battery is disconnected for any reason at all.

The starting motor switch is mounted on top of the starting motor and operated by a rod which leads to a ring in the cowlboard in front of the driver.

An ammeter is mounted on the cowlboard and indicates the charge and discharge current of the battery except the current taken by the starting motor.

A battery ignition system is used, and it is controlled by an ignition switch mounted on the cowlboard.

CHAPTER XXXI

Bosch-Rushmore Electrical Systems

THE generators made by the Bosch and Rushmore companies have their output regulated by either of two methods, namely, the bucking field type of regulation or the electromagnetic type of regulation.

Bucking Field Type of Regulation

These generators are of the round frame, two-pole type, and each of the poles has a series and a shunt winding. The voltage of the generators may be either 6 or 12 volts, depending on the installation, and the system may be of the single or two-wire type. The connections of the windings are such that the magnetizing action of the series turns opposes the magnetizing action of the shunt turns in the majority of cases. In some of the systems built previous to 1917, the series field winding is shunted by a coil of iron wire, called a ballast coil, whose action is as follows:

When the output of the generator is low the ballast coil carries practically all the current the generator is delivering. As the current output increases the iron wire composing the ballast coil begins to heat and its resistance increases, thus causing more current to pass through the series field, which tends to lower the

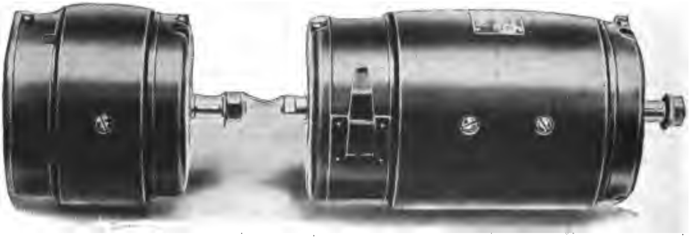


Fig. 308—*Two styles of dynamo used with Bosch standard lighting systems. The smaller, frequently called the fan-type dynamo, is type DSR*-103 *and the larger DSR*-3

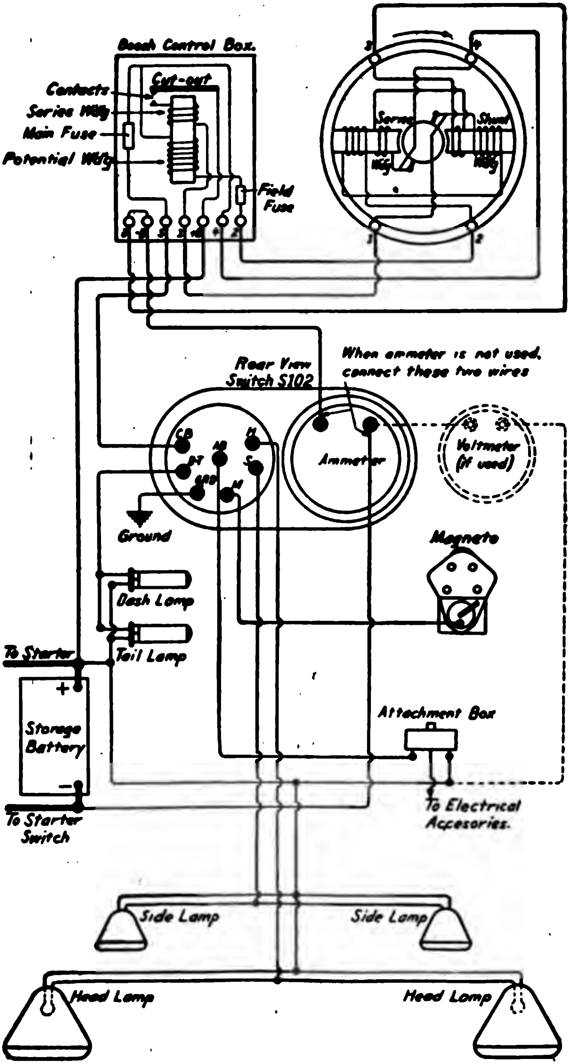


Fig. 309—Wiring diagram of Bosch standard installation using DSG generator, CBG-102 control box and S-102 lighting switch

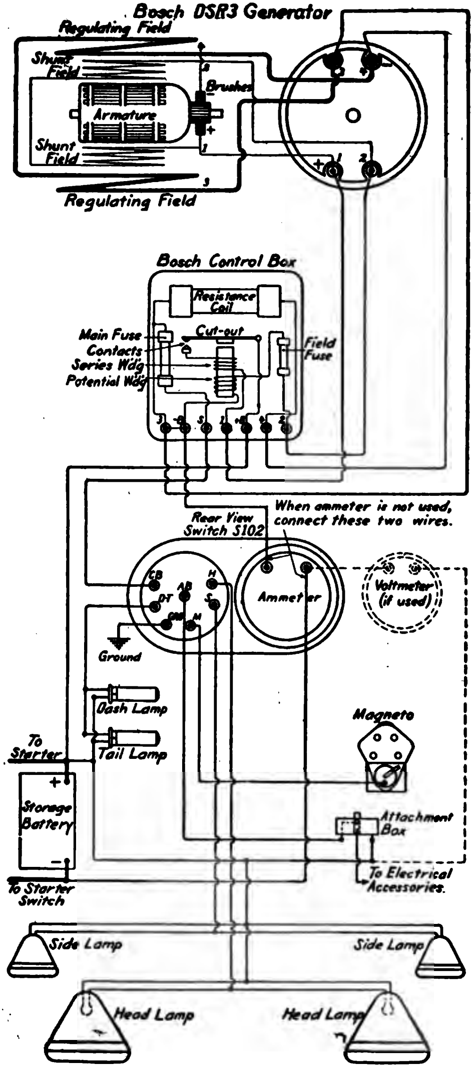


Fig. 310—Wiring diagram of Bosch standard installation using DSR-3 generator, CBG-101 control box and S-102 lighting switch

output of the generator. The maximum current the generator will deliver may be changed by replacing the ballast coil with one having a different resistance and thus the generator output may be adjusted to meet the demands on the storage battery. Two types of Bosch generators are shown in Fig. 308. The smaller one, which is frequently referred to as the fan-type generator, is known as type D S R-103 and the larger one as type D S R-3.

The wiring diagrams of two typical Bosch installations are shown in Figs. 309 and 310.

The generators that do not use the ballast coil are very similar in construction to those that use it. In two generators of this type, D S G-105 and D S G-106, the lamps are connected in series with the series field coils and the series field carries current only when the lamps are burning. In these two machines the magnetizing action of the series field assists the magnetizing action of the shunt field. Two different types of control boxes are furnished with these systems. Type C B-101 contains the cutout, the ballast coil, the shunt field fuse and a main fuse which carries

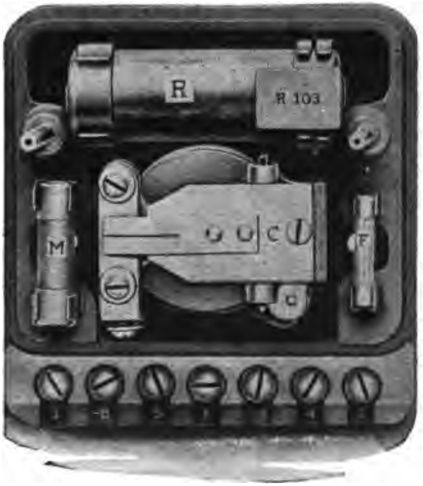


Fig. 311—*Bosch standard lighting system control box, type CB*-101, *with cover removed: C, cutout; F, field fuse; M, main fuse; R, resistance coil* the entire lighting current. A view of a control box of this type with the cover removed is shown in Fig. 311. The installations on some cars, such as the Marmon, are not provided with this large fuse, but separate fuses are provided in each of the lighting circuits. The G B G-102 type of control box is identical except no ballast coil is provided. A metal strip is connected in place of the coil.

Two types of switches are provided. In one type the lighting and ignition switches are combined, and in the other type this switch is combined with an ammeter to form a unit. A front view of both types of switches is shown in Fig. 312.

The Bosch and Rushmore starting motors are practically the same. The construction of the motor is such that its armature is moved endwise when the starting switch is closed and the driving pinion is brought into mesh with the gear on the flywheel. The operation of this system of driving is fully described in the section on "Motor and Engine Connections."

Electromagnetic Type of Regulation

The generators for these systems are shunt-wound machines, and an external regulator is provided. This regulator consists of a solenoid whose plunger stands in a vertical position and is held down by a spring. The end of this plunger rests upon a mass of carbon and mica which forms part of the field circuit. The wind-

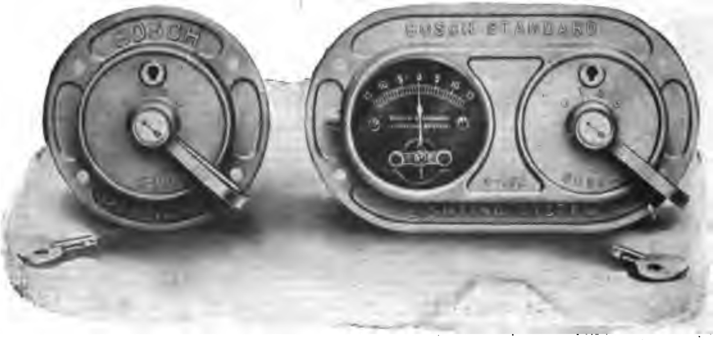


Fig. 312—Two styles of switches supplied with Bosch standard lighting systems. Type S-101 is without ammeter; type S-102 is with ammeter. Both incorporate a locking device

ing of the solenoid is connected across the generator brushes, and as the voltage of the generator increases the plunger is raised and the pressure on the mass of carbon and mica is decreased, which results in the resistance of the field circuit being increased. The increase in field resistance causes a decrease in field current and hence a decrease in generated voltage. The regulator, automatic cutout, lighting switch and ammeter are combined in a single unit and mounted on the dash. The voltage of these systems may be either 6 or 12 volts.

Bosch Ignition and Lighting

The Bosch ignition and lighting system combines in one unit a high-tension magneto and a direct-current shunt-wound lighting generator. Each electric source is absolutely independent of the other, and except for the fact that the two units are combined in one housing they are to all intents and purposes entirely distinct. Either one can operate independently, and the operation or non-operation of one does not in any way affect the other.

Fig.* 313—*Bosch ignition lighting unit type G3N4 for motor cars

The ignition section is a true high-tension magneto. The connections comprise only the necessary cables between the magneto and spark plugs. There is no coil, no separate timer and no complications of wires. The battery is used only in the lighting circuit and in no way is a part of the ignition system or assists in the generation of ignition current.

The generator section is a direct-current shunt-wound machine while charging but is arranged with an extra series of field, which is connected in series with a lighting switch, so that all the lighting current passes through the series field and materially increases the output of the machine when running under loaded conditions.

The wiring is very simple, but one cable from the generator to the battery and a second cable from the generator to the distribution switch.

The Bosch ignition-lighting unit shown in Fig. 313 is for use on motor cars and the one shown in Fig. 314 is for use on motorcycles.

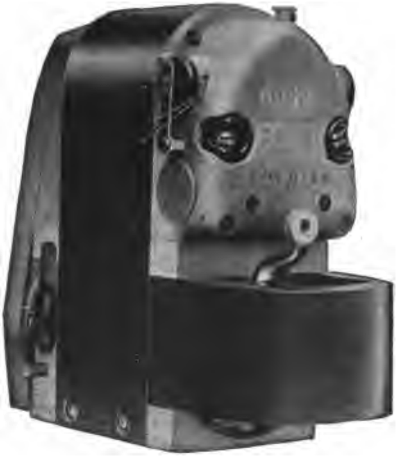


Fig. 314—Bosch ignition-lighting unit type GIEV for motorcycles

CHAPTER XXXII

Dyneto Electrical Systems

THE generator for the Dyneto two-unit, 6-volt, single or two-wire system is a four-pole shunt-wound machine whose output is regulated by an electromagnetic type of regulator or by the third-brush method, depending upon the type of machine used. The circuit between the generator and the battery is controlled by an electromagnetic cutout, combined with the regulator, when a regulator is used. A section of this combined unit is shown in Fig. 315, and a diagram of the connections is given in Fig. 316. The winding A, Fig. 315 is connected across the terminals of the generator, and as the voltage of the generator builds up the current in this winding increases in value until the armature B is

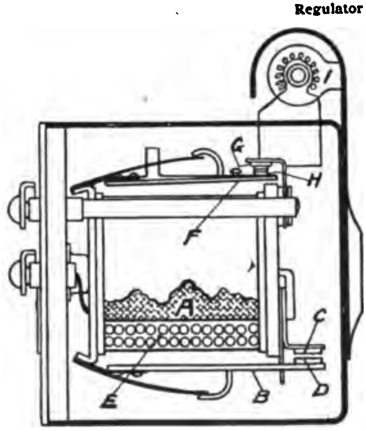


Fig. 315 — *Cross-section of Dyneto combined cutout and regulator*

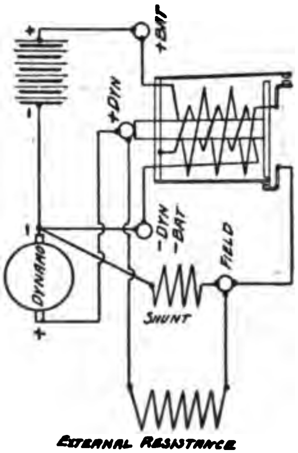
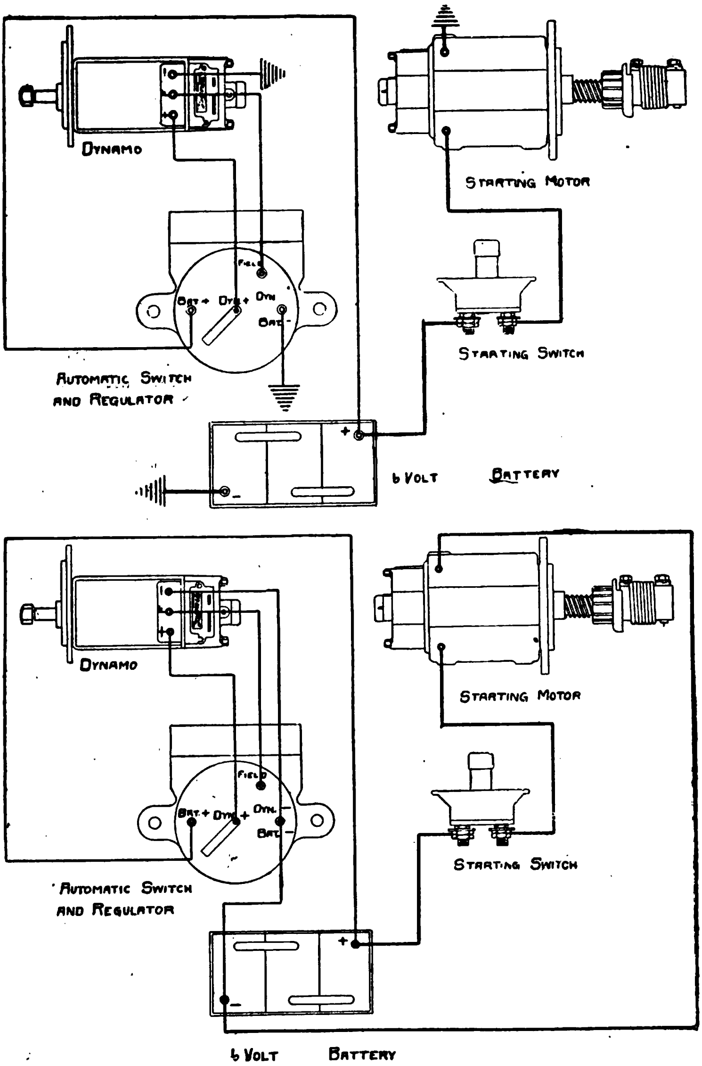


Fig. 316—*Wiring diagram of Dyneto combined cutout and regulator*



Figs. 317 *and* 318—*Wiring diagrams of Dyneto single-wire, upper, and Dyneto two-wire, lower, systems*

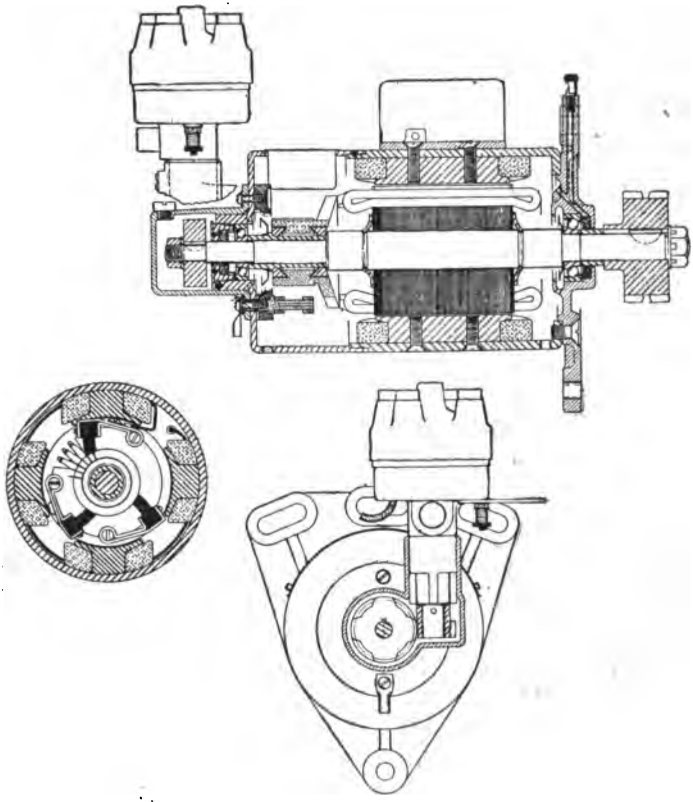


Fig. 319—Sectional view of Dyneto type CA generator equipped with an ignition head and automatic cutout mounted on top

drawn up and the contacts C and D brought together. When the contacts C and D are brought together a circuit is completed through the generator, battery and the coil E, which is made of heavy wire and comparatively few turns. While the generator is charging the battery the magnetizing actions in the two coils assist each other, and as the charging current increases this magnetizing action increases. The magnetizing action finally reaches a value ample to draw the armature F from its normal position and thus causes the points G and H to separate. These two points are connected directly in the shunt-field circuit and when they are separated a resistance I, which is connected directly across the points, is introduced into the field circuit.

The wiring diagrams of a single- and two-wire installation are shown in Figs. 317 and 318, respectively. In both of these installations the combined cutout and regulator are mounted separate from the generator. In systems using the third-brush type of generator the automatic cutout is mounted separate from the generator, or on top of the generator, depending on the installation. A generator of the third-brush type having the cutout on top and provided with an ignition head is shown in Fig. 319.

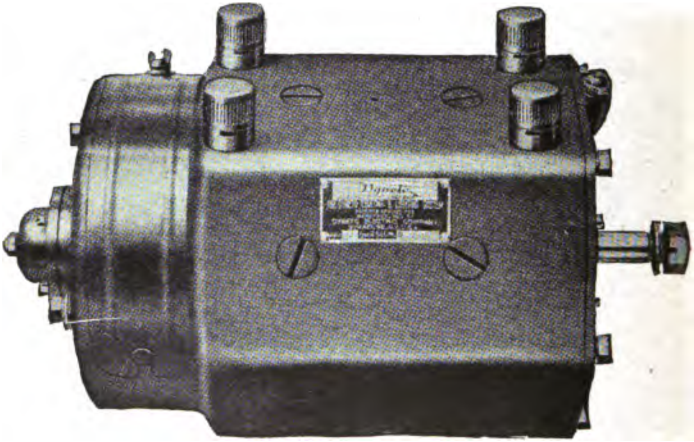


Fig. 320—*Dyneto combined generator and motor*

In the single-unit, 12-volt, two-wire system used on Franklin cars both generator and motor actions are provided in a single machine, mechanically connected to the crankshaft of the engine by a silent chain with a gear reduction of about 3 to 1, depending on the particular installation. The electrical unit has six poles, and both a shunt and series field winding provided. A view of the electrical unit is shown in Fig. 320. The output of the unit when

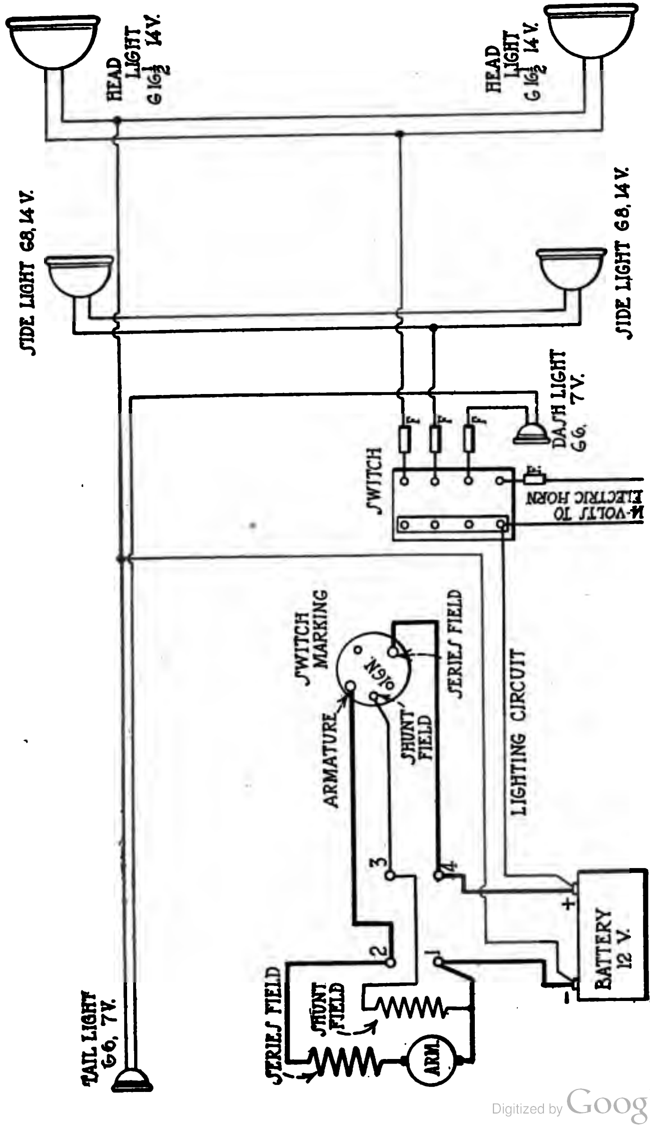


Fig. 321—*Wiring diagram of Dyneto single-unit 12-volt single-wire system* operating as a generator is controlled by a combination of the third-brush and bucking field methods.

A typical wiring diagram of a system of this kind is shown in Fig. 321. A front view of the starting switch is shown in Fig. 322, and it is mounted on the dash within easy reach of the driver. This switch has three positions marked "off," "neutral" or "touring" and "start." The ignition circuit is controlled by this same switch. The neutral, or touring, position is for long drives with a fully charged battery, and with the switch in this position the ignition system is in operation, but the generator will not charge the battery. When the switch is in the starting position the battery and electrical unit are connected directly together and the battery will charge as long as the voltage of the electrical unit is above the voltage of the battery. When the voltage generated in the armature winding of the electrical unit is less than the voltage of the battery, the battery will discharge and the electrical unit will act as a motor and transmit power to the engine.

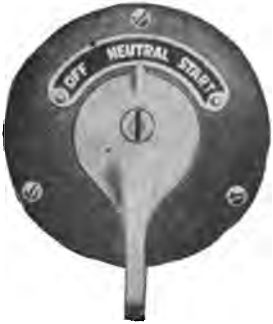


Fig. 322—Dyneto starting switch

No fuses are provided in the main circuit, but the different lamp circuits are fused separately as indicated.

CHAPTER XXXIII

Heinze Electrical Systems

THE generator in the Heinze two-unit, 6-volt, single-wire system is a rectangular frame, four-pole, 6-volt machine, and a shunt winding is provided on each of the field poles. An ignition breaker and distributer are mounted on the commutator end which is opposite the drive end. The generator complete is shown in Fig. 323.

The output of the generator is regulated by an electromagnetic regulator combined with the electromagnetic cutout. The combined cutout and regulator, together with the ignition coil, may be mounted on top of the generator or they may be mounted on the engine side of the dash.

The starting motor is a rectangular frame, four-pole, series-

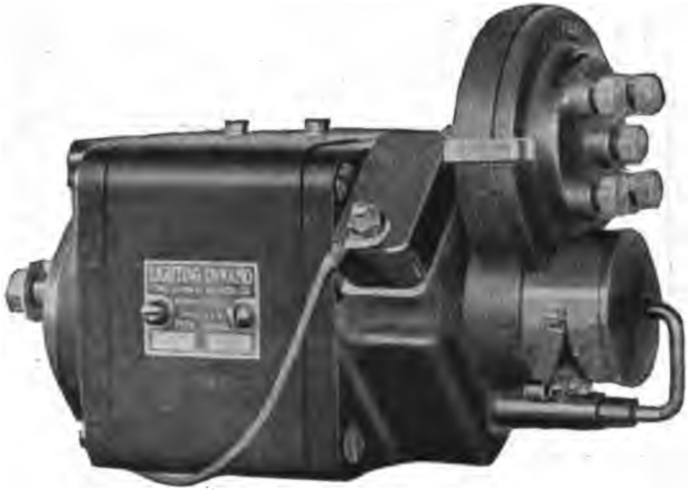


Fig. 323—Heinze generator with ignition breaker and distributer mounted on one end

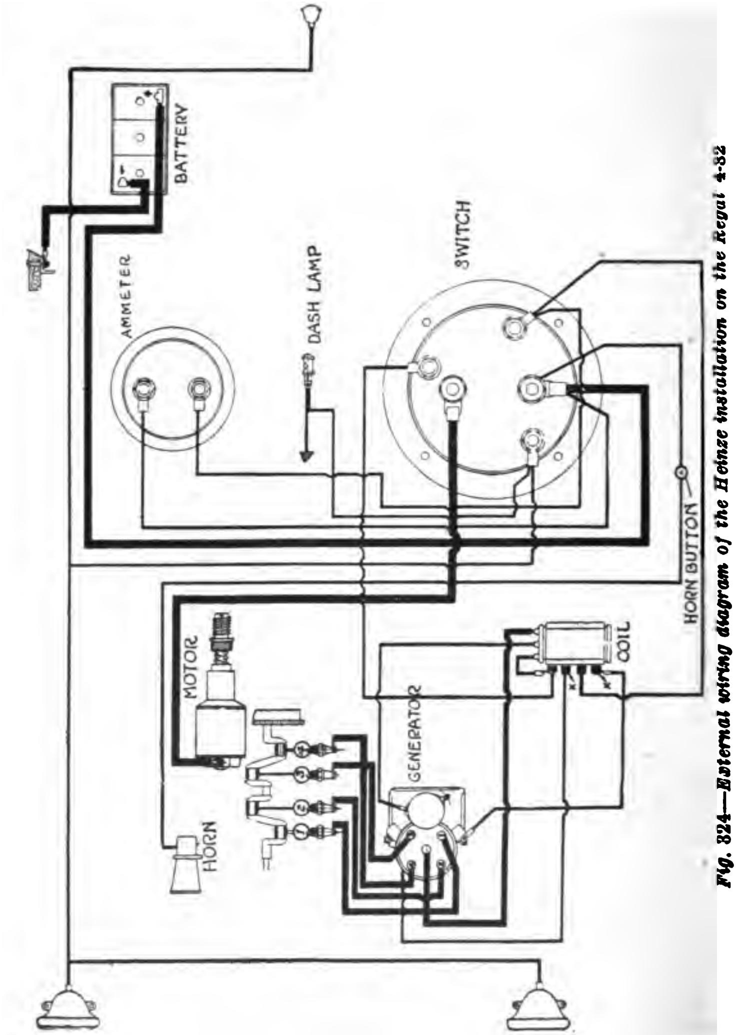


Fig. 324—External wiring diagram of the Heinze installation on the Regal 4-32

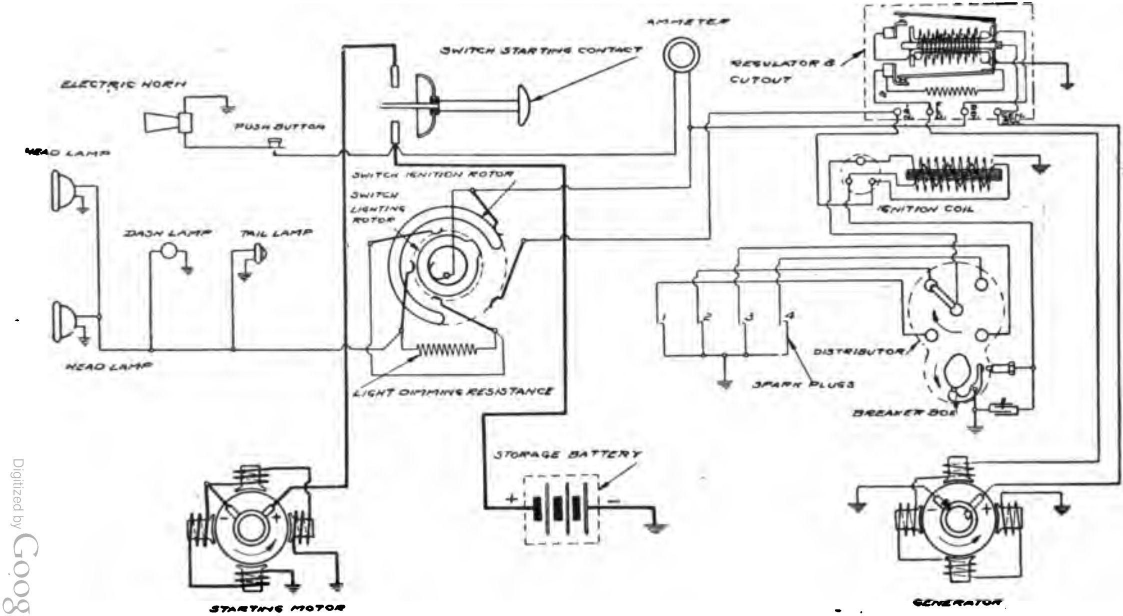


Fig. 325—Internal wiring diagram of the Heinze installation on the Regal 4-32

wound, 6-volt machine very similar in appearance to the generator.

The combined starting, lighting and ignition switch is mounted on the dash within easy reach of the driver. The starting switch is operated by a button which projects through the center of the main switch, while the lighting and ignition circuits are operated by a rotating arm. The resistance for dimming the headlights is inclosed in the switch.

Typical Heinze Installation

Two wiring diagrams of the Heinze installation on the Regal 4-32 car are given in Figs. 324 and 325. The external connections are shown in Fig. 324 and the internal connections are shown in Fig. 325.

CHAPTER XXXIV

Allis-Chalmers Electrical Systems

THE generator and motor functions may be performed by the same machine or they may be performed by entirely separate machines. The single-unit system, however, is the more commonly used equipment for motor cars.

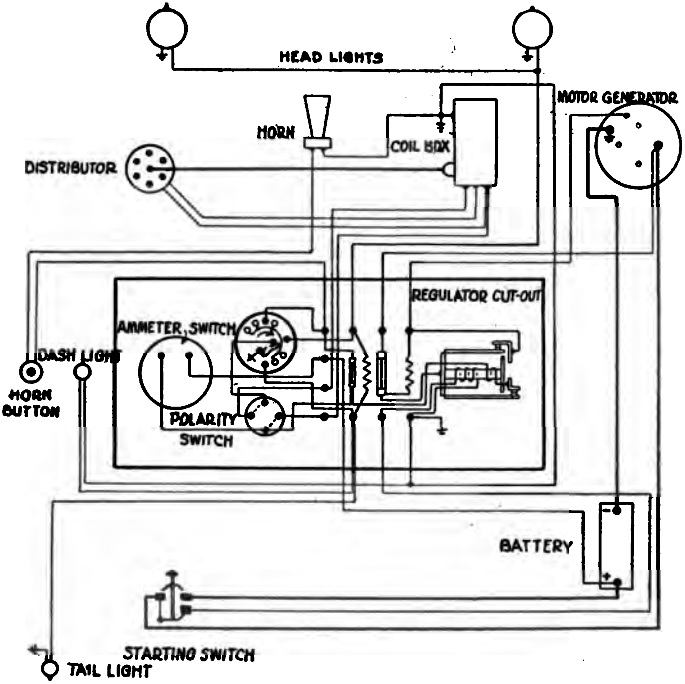


Fig. 326—Wiring diagram of Allis-Chalmers installation on the Grant six

Single-Unit, 6-Volt, Single-Wire

The electrical unit for this system consists of a compound wound four-pole combined generator and motor. The armature shaft of the electrical unit is connected to the engine crankshaft by a silent chain or reduction gearing and no overrunning clutch of any kind is used.

The output of the electrical unit when operating as a generator is regulated by an electromagnetic type of regulator. The regulator and electromagnetic cutout are combined in a single unit. Two types of combined cutout and regulator are used. One type is mounted in a rectangular box, and the other type is mounted in a cylindrical metal box.

Installation on Grant Six

A wiring diagram of the Allis-Chalmers installation on the Grant six is shown in Fig. 326. This is a single-unit, six-volt, single-wire system. The Atwater-Kent ignition system is used.

CHAPTER XXXV

Disco Electrical Systems

GENERATOR and motor actions in the Disco single-unit, 12-volt, single-wire are combined in a single unit whose armature is connected mechanically to the engine crankshaft. The electrical unit is a two-pole machine with a series and shunt winding on each of the poles. Sectional views of the generator are shown in Fig. 327. The regulation of the output of the machine when operating as a generator is by a combination of electro-

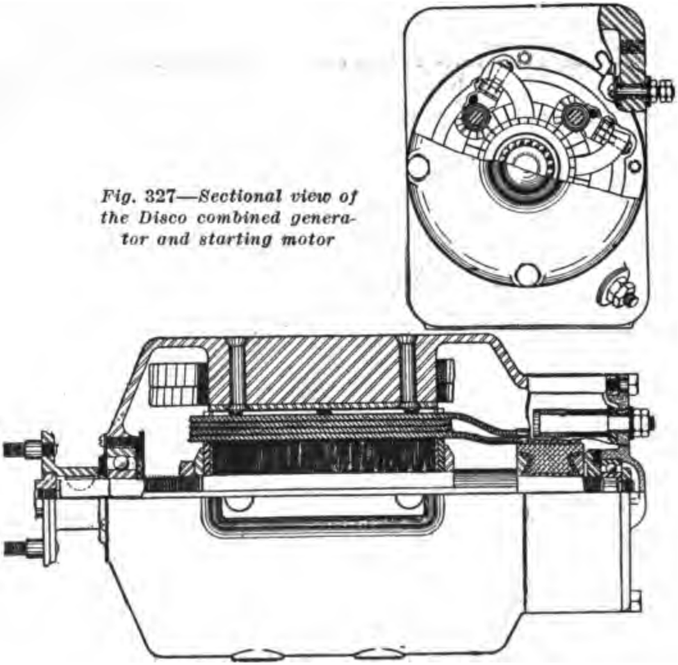


Fig. 327—Sectional view of the Disco combined generator and starting motor

magnetic and bucking field types of regulation. A Ward-Leonard type CD combined cutout and regulator is used. A wiring diagram of a system of this kind is shown in Fig. 328.

Two-Unit, 6- or 12-Volt

The Disco two-unit system makes use of both rectangular and round frame generators and motors, and they operate at 6 or 12 volts, depending on the installation. In some installations the two units are mounted above each other, and they usually are connected direct to the crankshaft by gears or silent chain and overrunning clutch. Both machines are bipolar. The generator is a compound-wound machine, and its output is controlled by the bucking field method of regulation. The starting motor is a series-wound motor. The circuit between the generator and the battery is controlled by a Briggs & Stratton cutout.

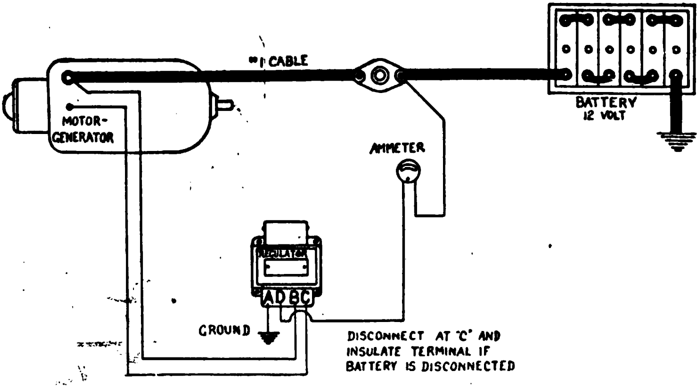


Fig. 328—Wiring diagram of the Disco single-unit installation

CHAPTER XXXVI

Ward Leonard and Detroit Systems

SEVERAL companies use equipment made by the Ward Leonard company, principally controllers, in combination with equipment made by themselves, such as generators and motors, and systems made up in this way are known by the name Ward Leonard, the name of the company, or combination of the two. Thus the Detroit-Ward Leonard equipment is a combination of Detroit and Ward Leonard equipment.

Ward Leonard Systems

The Ward Leonard systems use a 6-volt, two-pole, shunt generator and a four-pole series-wound starting motor. The output of the generator is controlled by a Ward Leonard controller.

Fig.* 329—*External view of type CC Ward-Leonard cutout and controller

In some installations the motor is connected to the engine by a Bendix drive, while in others a special pinion is used, and this pinion is operated by the pedal connected to the starting switch.

Several types of controllers have been made by the Ward Leonard company, and three of them are known as type E, type CC and type CD. The type E is used with the Ward Leonard system and the other types sold to companies who did not make their own controllers. Two electromagnets are used in the type E controller, one for the cutout and one for the regulator. In the types CC and CD one electromagnet is used, and the only difference in these two types is that the type CD has the resistance coil mounted externally. An external view of the type CC cutout and regulator is shown in Fig. 329.

Detroit Electrical Systems

The Detroit Starter Co. make both a single- and two-unit system. The single-unit system has three terminals and usually is mounted on a bracket alongside the engine and connected to the engine or crankshaft by a silent chain. A type CD Ward Leonard controller is used to regulate the output of the machine when it is operating as a generator.

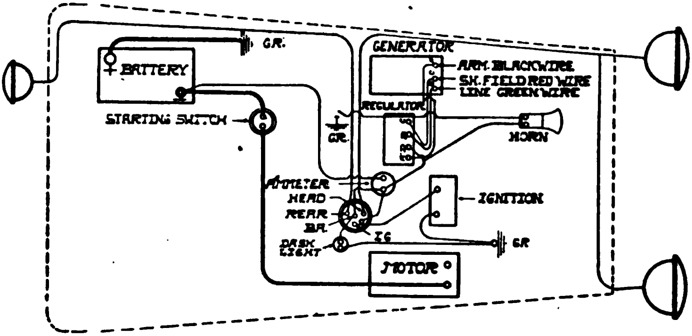


Fig. 330—*Detroit installation on the Saxon six*

The two-unit system is very similar to the Ward Leonard system described. The generator element is a two-pole, rectangular-frame, shunt-wound machine, and a type CC Ward Leonard controller is used in regulating its output. The motor is a two-pole rectangular-frame, series-wound machine, and a Bendix drive is used in connecting it to the engine.

The wiring diagram of a Detroit installation on a Saxon six is shown in Fig. 330. This is a two-unit, 6-volt, single-wire system.

CHAPTER XXXVII

Maintenance and Repair of Electrical Equipment and How to Diagnose Electrical Troubles

PART I

Points on Maintenance and Repair

ELECTRICAL troubles may be divided roughly into three classes, namely, troubles due to wear of so-called wearing parts, derangement of the wiring and connections and internal electrical defects. Of these the average garage repairshop should be equipped to handle the first two, while the last mentioned class should be taken care of in electrical service stations or repairshops. To do the ordinary electrical repair work remarkably little equipment is needed beyond that found in every machine shop.

Soldering Joints in Wiring

A good part of all electric work consists in making soldered joints, and a soldering outfit is a first requisite. This consists of a soldering iron, Fig. 331, or, preferably, several soldering irons of different size, a supply of solder in wire form and soldering fluid or flux. In most of the work the ordinary soldering flux, consisting of a solution of zinc chloride, can be used, but where a high degree of insulation is required and where soldered joints have to be made to parts of different electrical pressure that are separated only by thin strips of insulating material, a non-acid flux, of which there are several on the market, sometimes is used. Rosin will serve the purpose. None of these special fluxes make the solder run as freely as the regular flux, as they do not dissolve the layer of metallic oxide on the surfaces to be soldered as quickly. The ordinary soldering flux usually is purchased in the form of a salt, and the fluid flux is made up as required.

When making a soldered joint between two wires, the insulation is pared off for a certain length, the wires are cleaned mechanically by sandpaper or emery cloth, twisted together, daubed with soldering flux by a stick or swab and soldered. In making joints between wires insulated with cotton or silk, commonly known as magnet wires, it is not necessary mechanically to clean off the ends of the wire, which is comparatively clean when the insulation is stripped off. But rubber or composition-covered wire should be scraped or rubbed off. The steps are shown in Fig. 332.

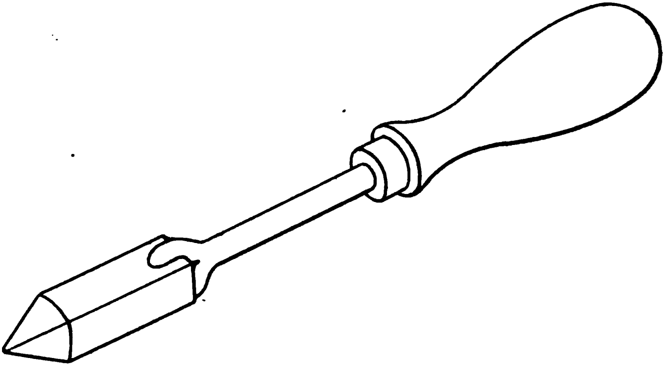


Fig. 331—*Soldering iron*

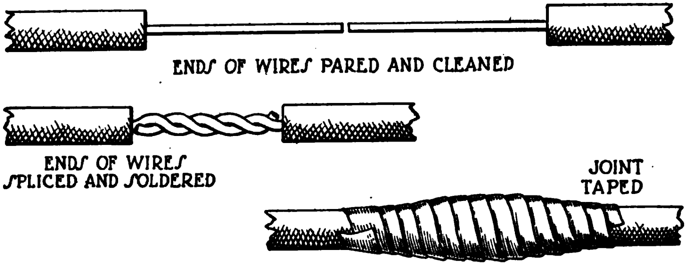

ENDS OF WIRES PARED AND CLEANED
ENDS OF WIRES SPLICED AND SOLDERED
JOINT TAPED

Fig. 332—*Various steps in making a wire joint*

Soldered and similar joints are insulated by adhesive or friction tape, which comes in rolls. This is wrapped around the wire in helix fashion, with successive turns overlapping. The tape is wrapped over a sufficient length of the wire at the joint to extend a short distance over the insulation on both sides of it. The warp of the tape fabric runs parallel with the tape, and the latter can be torn readily into two or even more strips if the size of the joint permits of more neatly wrapping the narrow strip than the full width of the tape. Owing to the adhesive quality of the tape, the end need not be especially fastened.

A connection between a wire and a stationary part never should be made by wrapping the bared wire around a screw or binding post and screwing a nut down upon it. Such a joint does not furnish a good connection. Besides the wire will break off after having been fastened and loosened a few times. Connectors should be soldered to the ends of the wires and drilled to pass easily over the binding posts. Such joints can be broken and remade any number of times without trouble, and, besides, they give a large effective contact area. See Fig. 333.

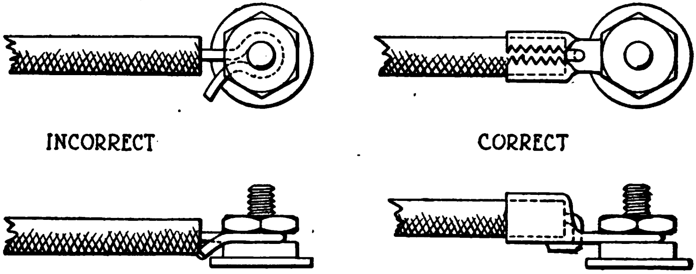


Fig. 333—*Methods of connecting to terminal posts, ground, etc.*

To insure the durability of the wiring no part of it must be subject to vibration. This is fully cared for in most modern machines, in which the wires are run through flexible metal conduits. When this is not used, it is well to fasten the wire down by cleats in a substantial manner. Also, in replacing parts of the wiring system wires of substantially the same size as the original one should be used. No. 14 B & S gage is used largely for lighting and charging circuits and No. 00 for starter connections.

In a ground return single-wire system there are many ground connections, and these are likely to give some trouble. The number of connections is no greater than in any insulated return wiring system, but in the latter case the conducting surfaces at the joint are usually both of non-corrosive metals, whereas the ground connections generally have to be made to parts subject to rust. An especially good ground connection has to be made in the starting motor circuit, as this has to carry a very heavy current, and a poor contact would greatly cut down the power and cranking speed of the starting motor. Therefore, if a starting motor seems to be not quite up to power, after having made sure by an hydrometer test the battery contains sufficient charge, the contacts and joints in the starter circuit should be examined, particularly the starter switch contacts and the ground connection joints. To secure the good electrical contact necessary for the starter ground connection, a brass plate often is riveted to the frame, and the connector lug on the ground wire is bolted to this plate. Besides being riveted the brass plate may be soldered to the frame, so rust or dirt cannot impair the contacts.

Care of Generators and Starting Motors

Charging generators and starting motors are virtually the same type of machine and subject to the same troubles. The bearings of both, of course, require oiling occasionally, but as these machines mostly are fitted with anti-friction bearings, only a small amount of oil is required, and no serious trouble is likely to result from lack of lubrication, as the only object of the lubricant in ball and roller bearings is to prevent rusting of the parts.

It has been a mootable question as to whether commutators should be lubricated. Some makers advise strongly against any lubrication, on the ground that excessive lubrication, which is always possible if an unskilled or careless person looks after the machine, gives rise to no end of trouble. The carbon brushes, as well as the commutator copper bars, wear away in service, and metal and carbon dust, which conducts electricity, accumulates within the generator or motor. If the interior of the machine is kept dry, this dust can be blown out at intervals, but if there is an excess of oil in the machine the dust will cake on the various parts, forming short-circuits, grounds, etc. On the other hand, it cannot be denied that a thin film of oil on the commutator will cut down the brush friction and reduce not only the heating of the commutator and loss of energy but also the wear of the commutator and brushes. The best way to apply the oil to the commutator, and at the same time make sure that there will be no excess of it, is to dip the finger slightly into the oil and then hold it to the commutator as the latter revolves.

Of the wearing parts of generators and motors those that require the most attention are undoubtedly the brushes. These must slide freely in the brush holders and yet must make good electrical contact with them. Where very heavy currents have to be carried, as in starting motors, some makers consider it inexpedient to depend on the frictional contact between the brush and the holder to conduct the current, and short flexible cables, known as pigtails, whose ends are fastened to the brushes and the holders respectively, are provided. In order that the electrical resistance between the brushes and the commutator may not be too great, the brushes must be pressed firmly against the commutator, and this is the object of the brush springs. With many designs of brush holders the pressure of the springs varies as the brushes wear down, and, therefore, when the brushes become too short they should be replaced. New brushes must be fitted or bedded to the commutator. To this end a strip of sandpaper is placed over the commutator under one set of brushes, with the paper toward the commutator. Then, while one man presses the brushes down, another draws the sandpaper back and forth over the surface of the commutator, thus wearing the contact surface of the brushes down until it nicely fits the contour of the commutator. See Fig. 334.

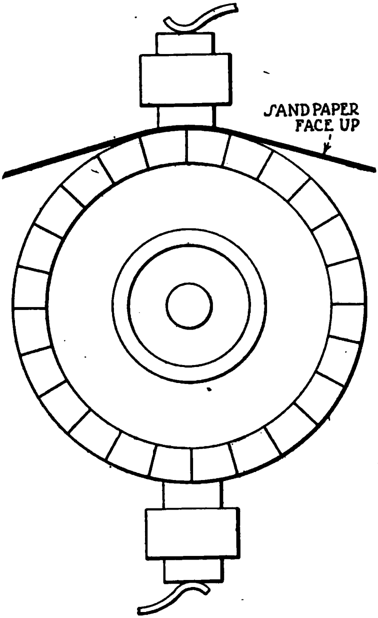


Fig. 334—*Bedding a new brush to the commutator*

Another wearing part of electric machines is the commutator.

This generally is built up of standard copper segments with strips of mica between for insulation. After the surface on which the brushes bear has become rough, it is impossible to secure good electrical contact, and the commutator then must be turned down in a lathe. This job can be done in any ordinary repairshop. The armature is removed from the machine and swung between centers in the lathe, and cuts are taken over the whole width of the bearing surface of the commutator until it is absolutely cylindrical, that is, until all signs of the old bearing surface have disappeared. At the inner end of the bearing surface, just in front of the commutator lugs, a shallow groove generally is cut, Fig. 335, the idea being that at least one of the brushes shall extend over the edge of this groove, thus preventing the wearing of a ridge on the bearing surface of the commutator.

The armature always has a slight amount of end play in its bearing, and if a ridge were allowed to form on the surface of the commutator, as the armature played back and forth in the direction of the shaft axis, the brush would clinch the ridge and thus partly break contact with the commutator, causing sparking. After the commutator has been turned down a couple of times, the bars or sectors become very thin, and it then becomes necessary to refill it. This involves the unsoldering of all the

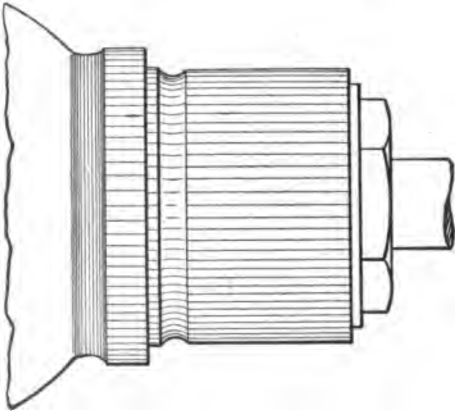


Fig. 335—*Groove at inner edge of the commutator* armature wires, called leads, from the commutator lugs and the removal of the commutator from the armature shaft.

The actual refilling of the commutator probably is best left to the maker's service station, as it would involve too much trouble for the repairman to get hard copper segments of the proper size, as well as sheet mica properly cut, besides making a special clamp for assembling the bars. Instead of refilling the old commutator sleeve a new commutator may be fitted. These come with the lugs already slotted for the leads, and all that has to be done after the commutator is fitted to the shaft is to solder the leads into the slots and possibly to put on a band. In soldering care must be taken not to produce a short-circuit between adjacent bars, or segments.

Sometimes it will happen that the mica plates between adjacent commutator segments project slightly above the surface of the commutator and prevent intimate contact between brushes and commutator segments. Mica is exceedingly hard and wears less rapidly than copper. The result is destructive sparking at the brushes. To obviate such trouble the mica may be undercut slightly below the surface of the commutator.

One of the causes of a generator failing to pick up is an open field circuit. After a thorough inspection of the brushes and when application of pressure to them has failed to remedy the trouble, the field circuit should be investigated. All generators of motor car electric systems, except those in which the field is produced by permanent magnets, have shunt field windings, and the break may be either in the windings at their connections to the generator terminals or in the regulating resistances sometimes connected in series with the shunt field coil. A test for continuity of the field circuit can be made by removing one set of commutator brushes and also disconnecting the battery cutout. Then the test points applied to the generator terminals should show a complete circuit through the field.

Regulating Generator Output

Some equipments are furnished with means for regulating the rate of charge, and this must be considered a very useful feature. Of some other adjustable motor car parts it is said that they are set at the factory and should never be disturbed, but this does not always apply to the charge-regulating device. Some operators drive under such conditions that very little current is used for starting and lighting but the battery is being charged nearly all the time the car is on the road. In this case there is naturally a tendency to overcharging. Overcharging results in a constant loss of energy, in the production of corrosive fumes from the battery electrolyte and deterioration of the battery. Other operators, who do much city driving at night, use a great deal of current for starting and lighting, and owing to legal and traffic conditions seldom can drive at a speed where the generator is sending its full charging current into the battery. In their case, therefore, a tendency to undercharging, is a much more serious matter than overcharging and also much more common.

An undercharged battery gives a dim light, is incapable of cranking the engine and deteriorates rapidly. Therefore, it is essential that the rate of charge be regulated to suit the conditions of operation. The most suitable rate of charge varies even with the seasons, as in summer less current is required both for lighting and starting, for lighting because of the relatively much longer period of daylight and for starting because during the warm season an engine cranks easier and picks up its cycle quicker than in extreme cold.

Care of Storage Battery

Two things in regard to the battery should receive constant attention if the battery is to be kept in condition. Distilled water must be added at intervals, and the battery always must be kept in a fair state of charge. The hydrometer test gives the most reliable information as to the amount of charge in the battery. Water is added by a rubber bulb siphon which permits of accurately adjusting the level of electrolyte in the cells.

Every garage owner who has direct-current service mains in his establishment should rig up a low-voltage battery-charging apparatus. This comes very handy in recharging ignition batteries and in "freshening" starting and lighting batteries from cars put up for the winter or when the generator will not keep up the charge. The material required consists of a couple of 10-ampere fuses, a double-pole single-throw 10-ampere knife switch, a rack containing seven or eight lamp sockets, a corresponding number of carbon filaments, 32-candlepower bulbs and some rubber-insulated wire about No. 14 B & S gage. As shown in Fig.

336, the fuses and switch are mounted on a board secured to the wall at a convenient height. The lamp rack also is secured to the wall, at such a height as to minimize the danger of injury to the bulbs.

From the mains wires are run to the fuses and from these to the upper terminals of the switch. From the lower terminals one wire is run to the battery to be charged and the other to the lamp rack. The lamp sockets all are connected in parallel, that is, one wire connects to one terminal of each lamp socket and another wire to the other terminal of each socket. The remaining lamp rack terminal is connected to the storage battery to be charged. This completes the charging circuit.

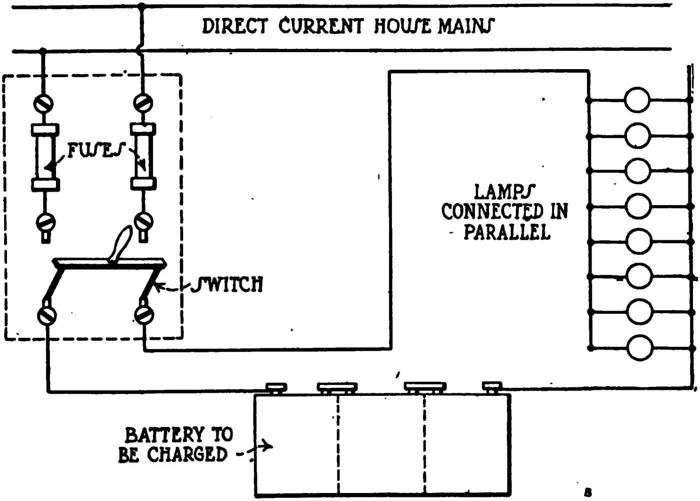


Fig. 336—*Battery charging outfit*

In order that current from the mains may flow through the battery in the proper direction for charging, the positive side of the line must be connected to the positive terminal of the battery. The battery generally is marked with a plus sign, but the positive side of the line has to be determined. One way is to hold the two wires to the battery terminals, first in one way and then in the other, and observe the lamps. The connection which gives the least light is the correct one. The reason for this is that when the battery is connected to the lines in the proper direction the battery voltage opposes the line voltage and the voltage on the lamps is equal to the difference beween the two, whereas when the battery is connected the wrong way the voltage of the line and that of the battery added together and the lamps will be more than usually bright. After the positive side of the line has been determined it should be marked on the switches so it does not have to be found every time it is desired to charge.

Another method of finding the positive side of the line is to place the two wires to be connected to the battery into a vessel with slightly acidulated or salted water, at some distance apart. Supposing the switch to be closed, the two wires will give off gas bubbles, and the one giving off the least gas is the positive wire and should be connected to the positive terminal of the battery.

PART II

Testing Equipment

The sudden advent of electrical equipment other than that required for engine ignition, some four to five years ago, confronted motor car repairmen with problems quite new to them. Of course, there had been a certain amount of electrical equipment on motor cars from the very beginning, but there is little comparison between the simple ignition system, especially the high-tension magneto system, with its minimum of exposed wiring, and the rather complicated system of wiring for a complete set of electric lamps, electric horn, starting motor, electric ignition and a self-contained electric generating system. The puzzling nature of many electrical troubles was foreseen by some of the pioneers of the industry, and its realization gave rise to the argument against electric ignition, voiced by Levassor among others, that on a gasoline motor car, everything—including ignition—should be accomplished by gasoline. Levassor and followers, however, proved to be wrong in this contention, as electricity has not only won a complete victory in the ignition field but also has found several other important applications.

In the case of electrical troubles the main thing is a quick and correct diagnosis. The trouble may be in any of the major parts of the system or it may be in the wiring. The nature of the trouble often partly locates it, at least approximately. For instance, if a single lamp will not burn, the trouble must be either in the bulb, socket or wiring of that lamp. It cannot be in the battery, the generator or the appurtenances of the generating system, because any fault in these parts would affect all the lamps alike. Similarly, if the starting motor refuses to crank the engine, the trouble—if the engine can be turned by hand—may be in the starter, its wiring, the switch, the battery or the generating system of the lamps burn properly, the trouble is not with the battery or generating system, and this test, therefore, limits the necessary search to the starter, the switch and the wiring.

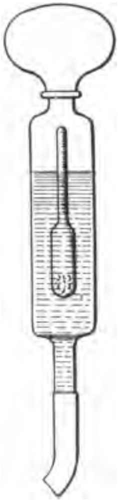


Fig. 337—Battery hydrometer

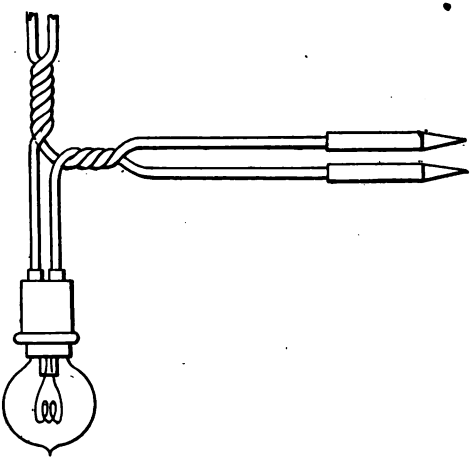


Fig. 338—Arrangement of testing lamp

To properly diagnose electrical troubles, it is necessary to have a certain number of testing instruments. For battery tests the most important is the battery hydrometer, Fig. 337. For convenience in battery testing, the hydrometer generally is placed inside a syringe or siphon by which a certain amount of electrolyte can be withdrawn quickly from each cell of the battery and as quickly restored. The syringe consists of a substantially cylindrical glass vessel with a spout at the bottom for insertion into the battery filling hole and a rubber bulb at the top. By compressing this bulb, then inserting the spout into the battery cell below the level of the electrolyte and then releasing the bulb, sufficient electrolyte can be drawn into the syringe to float the hydrometer. The latter is an instrument for determining the specific gravity of a liquid. It is based on the physical law that a floating body displaces as much liquid as is equal to its own weight. As the hydrometer has a definite weight, if the liquid in which it is immersed is relatively light, it will sink into it to a greater depth, thus displacing a greater volume of it than if the liquid is relatively heavy.

The stem of the hydrometer is graduated to show the specific gravity of the liquid in which it is immersed, at the level of the liquid. Pure water has a specific gravity of 1.000 and pure sulphuric acid has a specific gravity of about 1.85. The extreme range of specific gravity of storage battery electrolyte is about 1.100 to 1.300. As the charge in the battery increases during the process of charging, the density of the electrolyte increases, and vice versa, as the charge decreases during the process of discharge, the density of the electrolyte decreases. At full charge the density of the electrolyte is about 1.280, and when a battery is completely discharged, the density is about 1.120. When the density is midway between these figures, the battery contains a half charge.

The simplest indication of a current flowing in a circuit is a spark obtained on breaking the circuit at any point. A storage battery has little internal resistance and the current from it usually is sufficiently intense to give a clearly visible spark when the circuit is broken. This method can be applied in various ways to determine whether or not a circuit is faulty.

Ammeter and Voltmeter

An ammeter and a voltmeter are handy instruments for tracing electrical troubles. Reasonably accurate instruments can be purchased now at comparatively low prices and in the hands of a man with some electrical knowledge are a great help. For instance, with every system of electrical equipment the charging current at certain engine speeds should have a certain value. Therefore, an ammeter test of the charging current at a given engine speed would show whether or not an electric charging system is operating as it should.

It may here be explained that an ammeter, or ampere-meter, shows the quantity of current in amperes flowing in a circuit, while a voltmeter shows the electrical pressure between the points to which the voltmeter is connected. An ammeter is perhaps of wider use in diagnosing troubles than a voltmeter. To be able to properly use these instruments, the operator has to be familiar with their method of connection. To measure the current flowing in any circuit, the circuit is opened at any point and the ammeter is inserted at the break. On the other hand, if it is desired to determine the voltage active in the circuit, the voltmeter must be connected differently. The highest measurable voltage in a circuit is at the terminals of the current source, such as the battery. Therefore, to measure the voltage of the battery, the two binding posts of the voltmeter are connected to the two terminals of the battery respectively. Some voltmeters and ammeters are polarized, that is, they have their binding posts marked plus and minus respectively, and these binding posts must be connected to the corresponding sides of the circuit. With other types of instruments, it does not matter which way they are connected in circuit.

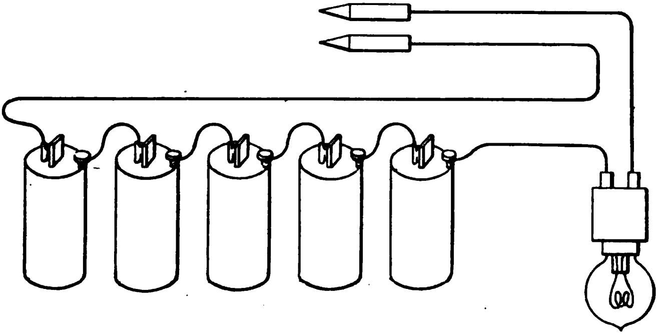


Fig. 339—Arrangement of low-voltage testing lamp

For determining and locating troubles in the wiring and parts of electric systems, use is made of one or the other of a variety of devices giving either a visible or an audible signal when a current flows through them. These include incandescent lamp bulbs, bells, buzzers and telephone receivers. The bulbs may be of the regular house lighting variety, 110-volts, and current from the service mains may be used. In that case it is preferable to use carbon filament bulbs, as these will withstand more vibration than tungsten filament bulbs, and though they take more current, this is of no consequence because the current used for testing is insignificant in any case.

The testing lamp is arranged as illustrated in Fig. 338. One of the two strands of the cord leading to the lamp is cut, usually close to the lamp, and to each end thus obtained is soldered a length of lamp cord 4 to 6 ft. long, the soldered joints being carefully taped with adhesive tape as used by electricians, to prevent them from coming in metallic contact. The other ends of these two wires are wrapped around and soldered to steel rods or spikes about 6 in. long, whose free ends are ground to a sharp point. The parts near the joint of the wire to the rod is heavily taped, partly to form an insulating handle for the operator and partly to prevent localization of bending at the junction, which would result in an early break. The object in providing the rods with sharp points is to permit an exceedingly high pressure in proportion to the area of contact being obtained, which will insure metallic contact in spite of any film of oxide or dirt with which the metal surfaces may be covered.

Instead of using current from service mains and 110-volt bulbs, current from a low-voltage battery, such as an ignition or car lighting storage battery, or a dry cell battery, may be used, together with a low-voltage lamp or bulb. The arrangement is substantially the same as in the previous case, the outfit including the battery, the lamp and a pair of contact pins, besides the necessary wiring, as shown in Fig. 339.

A dry cell battery of five cells is somewhat more convenient for this work than a storage battery, mainly on account of its lower weight but also on account of its greater cleanliness. Though modern storage batteries are practically non-slopping, the dry-cell battery has absolutely no free electrolyte, which is better. A dry-cell battery also is better adapted than a storage battery to the service of furnishing momentary currents at more or less extended intervals, because it deteriorates less rapidly during periods of non-use. Of course, where current is required more or less continuously and in considerable quantity, the storage battery has the advantage.

Some testers prefer devices that give an audible indication, and in this class belong the bell and buzzer, Fig. 340, on the one hand, and the telephone receiver on the other, Fig. 341. The handiest form of the latter type of instrument is the head receiver as used by telephone operators at telephone switchboards. It has the advantage that it does not have to be held in the hand and leaves both hands free for manipulating the test points and making and undoing connections. Whether a bell, buzzer or telephone receiver is used to indicate current flow, a battery must be provided to furnish the operating current. A couple of dry cells will give a clearly audible signal with any of these devices.

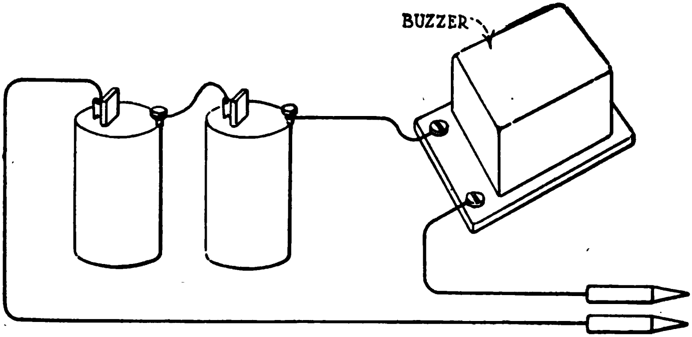


Fig. 340—*Buzzer test set*

Current indicators giving an audible indication are preferable to lamps, especially where continuous tests have to be made, as in testing out the different sections or coils of an armature. In bright daylight an incandescent lamp lighting up does not strongly impress the eye, and if the testing points are moved quickly from one section to another, the observer is apt to fail to notice the light signal. Another consideration is that the operator has to have his eyes on the points when establishing contact and then must look at the bulb to see whether it is lighted up, whereas with an audible signaling device he need not remove his eyes from the contact points.

Because of the low voltage of the batteries, the testing devices described are not well suited in case a fairly high degree of insulation is required. It is then better to use a testing magneto. This is nothing more or less than a telephone magneto with a bell and with two lengths of cords with test pins attached, Fig. 342. The magneto is cranked by hand and gives a very high voltage which will force a current through poor connections or leakage paths. Such a testing magneto, if much testing has to be done, should be operated by two persons, a boy turning the crank while the tester manipulates the test points.

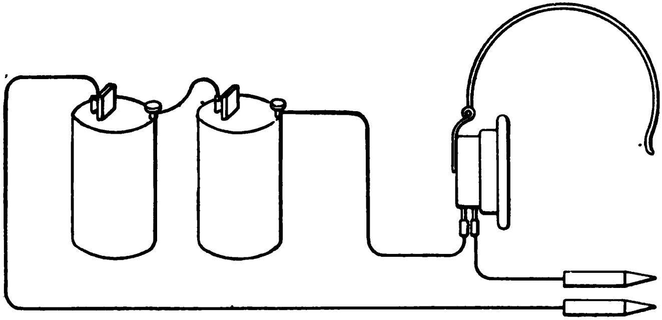


Fig. 341—*Telephone test set*

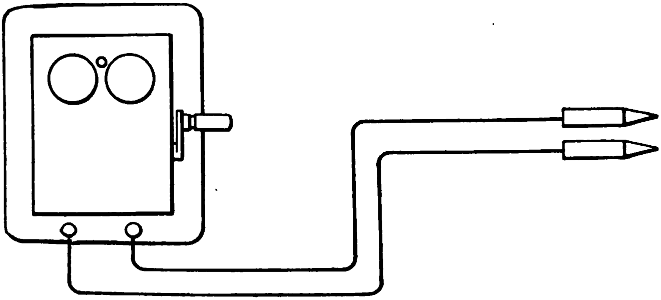


Fig. 342—*Testing magneto*

Partial List of Testing Apparatus

Hydrometer syringe, Fig. 337.
Testing lamp, using current from service mains, Fig. 338.
Testing lamp, using battery current, Fig. 339.
Testing buzzer, Fig. 340.
Testing telephone, Fig. 341.
Testing magneto, Fig. 342.

PART III

Classiffication of Troubles—Simple Tests

Electrical troubles may be either in the major parts of the electrical equipment or they may be in the wiring connecting these parts. There are essentially four classes of general electrical troubles, namely, an open circuit, a short-circuit, a ground and a poor connection, which latter is an incipient form of open circuit. An open circuit is a circuit with a break or interruption in it at any point. Voltages of the order used for lighting and starting will force a current only through a continuous or unbroken circuit of conducting material. If the circuit is open, no current can flow. The most familiar forms of an open circuit are a broken lamp filament and a burned-out fuse. Of course, the term "broken circuit" usualy is applied only if there is a break in the wiring outside the main parts of the system or at the connections. If there are any poor connections in the circuit, the result is that the resistance in circuit is greater than it should be and the current flow will be reduced.

A short-circuit is a derangement of the wiring or other parts of the circuit which allows current from the source, that is to say, fom the battery or generator to return to it without flowing through the connecting devices such as the lamps. A complete short-circuit prevents current from flowing through the consuming device. For instance, if the two wires connecting to an incandescent lamp are bared of insulation and twisted together where they enter the lamp socket, no current can flow through the bulb. A complete short-circuit results in an excessive current flow and a rapid drain of the battery, if not the fusing of the wires. A partial short-circuit, often referred to as a leak, may not greatly interfere with the operation of the consuming devices but will result in the waste or loss of energy, and as such is objectionable.

A ground is a metallic connection between the insulated wiring of the circuit and the metallic mass of the chassis or engine. A distinction must here be made between the two wiring systems used in connection with electrical equipment, the insulated return system and the ground return system. With an insulated return or two-wire system a ground on one side of the line is not immediately harmful, as it does not interfere with the operation of the system. No battery current can flow into the frame of the car or engine, because there is no return path. However, if another ground should develop on the other side of the line, the two grounds together would form a short circuit which would drain the battery and deprive the part to which the grounded wires are connected of current. For this reason it is always desirable to keep an insulated return wiring system entirely free of grounds, which are really incipient troubles. In the case of ground return wiring, as now used with the great majority of lighting systems, a ground on the insulated line is really a short-circuit.

It must not be understood that short-circuits, open circuits and grounds occur only in the wiring of a car. They may also occur in the different parts of the equipment. It already has been stated that burned-out bulbs and blown fuses are cases of open circuits, and there are plenty of chances for short-circuits to develop in such parts as the generator and starting motor.

Suppose it is suspected that there is a short in, say, the lighting circuit. This can be tested out by any of the testing outfits already described. When all the bulbs are unscrewed from their sockets no current should flow through the wires connecting to the lamps, and if a current does flow, it proves that there is a short-circuit. Therefore, remove all of the bulbs from their sockets, close all lamp switches, open the circuit at the battery by removing one connector from the battery terminal and touch the test points to the connector removed and the other battery terminal as indicated in Fig. 343. We will assume the lights are wired on the insulated return principle, or two-wire. Then if the test lamp lights up when contacts are made as described, it proves that current can flow from one side of the circuit to the other though all of the bulbs are removed; consequently, there must be a short-circuit somewhere on the line. To locate the exact position of the trouble requires additional tests which will be described further on.

To determine whether there is a ground on the circuit, all the bulbs should be left in place, the lamp switches turned on and the two test points connected respectively to any bare part of the circuit and a part of the frame. The connections are shown in Fig. 344. If there is no ground, no current can flow through the lamps, and it will not light. Now suppose there is a ground at A. Then the test lamp will light up and the path of the test current easily can be traced. It does not matter whether or not the ground is on that side of the lighting circuit to which the test point is touched, the test lamp will light up in either case. The location of the ground also calls for either a careful inspection of the whole line or for further tests.

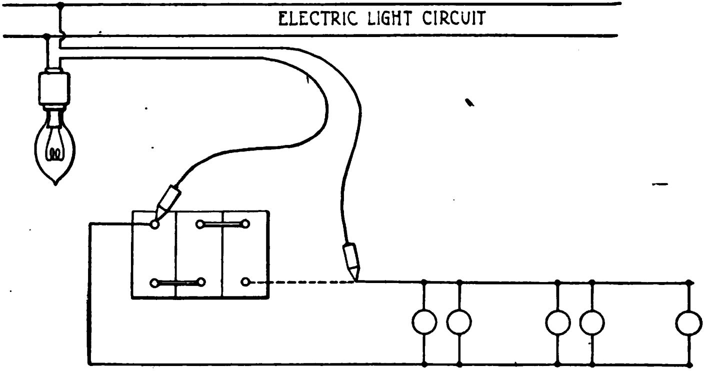


Fig. 343—Method of testing for a short in a lamp circuit by a testing lamp

Open circuits always manifest themselves in an unmistakable manner. For instance, if there is a break in a lamp circuit, the lamp cannot burn. If the break is in one of the main wires, of course all the lamps will go out, whereas if the break is in one of the branch circuits, only the lamp or lamps on that particular branch will become extinguished. Thus some indication as to the location of the trouble is furnished by its effects.

About the only test that needs to be made on the battery is the hydrometer test. Normally this shows the state of charge of each cell. Failure of the battery to maintain its charge is, of course, responsible for a great many difficulties. A battery cannot keep its charge unless it is kept filled with electrolyte to the tops of the plates. No fresh electrolyte needs to be added, however, as all loss by evaporation consists solely of water. Therefore, if the electrolyte does not cover the plates, distilled water should be added until the plates are completely covered. There is, of course, a bare possibility of some sulphuric acid being lost by a cell, as by failure of the tester to replace the electrolyte withdrawn for making an hydrometer test. To make a conclusive test as to the density of the electrolyte, the battery should be charged and the charging operation continued at a moderate rate until three or four successive hydrometer tests at intervals of 10 minutes show no further increase in the density of the electrolyte. Then the battery is completely charged. Different battery makers are somewhat at variance as to the density which should be indicated under this condition, but 1.280 to 1.300 is a good average figure. If the hydrometer shows less, remove

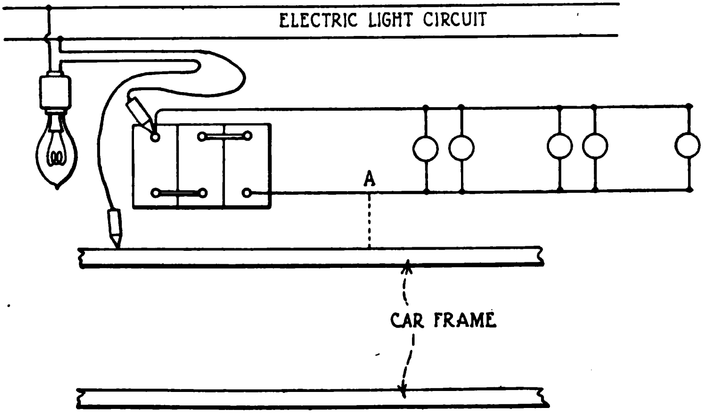


Fig. 344—Method of testing for a ground in a lamp circuit by a testing lamp

some of the electrolyte with the syringe and replace with electrolyte of extra strength. If it shows more, replace with distilled water.

Some precautions must be observed in making hydrometer tests to be sure of accurate results. Readings never should be taken immediately after distilled water has been added to the cells, as it is most unlikely that the water added is distributed uniformly throughout the old electrolyte. Make a test before adding the water and again after the water has been added and the battery charged. It is, of course, not sufficient to make a test of one cell only and take it for granted that the condition of the others is the same. Each cell should be tested separately. To avoid omissions, it is well always to start with the cell at the positive end of the battery and test all cells consecutively, returning the electrolyte drawn from any cell to that same cell. In taking the reading, it is well to see that the hydrometer does not contact with the wall of the syringe but floats centrally therein so as not to impair the accuracy of the indication.

The hydrometer test only shows the state of charge of the battery. It is desirable always to have the battery as near to the state of complete charge as consistent with the conditions of current demand, because battery elements deteriorate least when fully charged. When a battery is chronically in a state of undercharge, it may be due to a fault in the battery, due to excessive current demand, due to conditions of operation admitting of little charging or due to derangement in the circuits or the charge control system. The most common fault in the battery is sulphated plates, which can be detected by inspection. A normal positive plate when the cell is charged has a chocolate brown color, but when sulphated the plate has a grayish color. The sulphates can be reduced by repeatedly charging and discharging the cell at a very low rate. Lead sulphate when not disturbed for some time hardens and prevents circulation of the electrotype, with the result that charging—which means the reduction of the sulphate to spongy lead and lead oxide—can proceed only at a very slow rate.

Open circuits and short-circuits are also possible in storage batteries. An open circuit most likely would be due to a cor- [illegible] terminal and a short-circuit to a large collection of sedi- [illegible] eaching to the lower edge of the plates and bridging same.

The former can be detected by a careful inspection; the latter will be indicated by an absolute failure of a cell to hold a charge, as shown by a hydrometer or a voltmeter test.

Occasionally a generator fails to pick up, that is, to start to generate. This is generally due to poor electrical contact between the commutator and the brushes. This in turn may be due to dirt on the commutator, a rough commutator, insufficient spring pressure on the brushes, etc. The simplest test is to press the brushes down on the commutator by hand. In case the trouble is with the brushes, this may cause the generator to pick up, as with increasing pressure on the brushes the brush contact resistance decreases. A permanent repair, of course, involves the elimination of the cause of the trouble.

If the commutator is very rough, it should be turned down in the lathe and sandpapered. If it is merely dirty, sandpapering alone will do, while if the spring pressure is too small, which is probably due to the brushes being nearly worn out, the latter should be replaced. Of course, failure to pick up may be due to other and more serious causes, such as a break in the field circuit, a burned-out armature, etc. The generator field readily can be tested by a test lamp or test bell, by disconnecting it from the generator terminals. If the lamp lights or the bell rings when the test points are touched to the end of the field winding, it shows that there is no break in the field circuit, and if the test lamp fails to light up or the bell to ring when one test point is touched to a part of the field winding and the other to the frame of the car, it shows that there is no ground in the field circuit.

One method of testing out a generator that will not pick up is to remove its driving connection, so it can rotate independently of the engine crankshaft, and then close the automatic switch or battery cutout by hand. This connects the generator to the battery and causes it to act as a shunt motor. If poor brush contact was the cause of its failure to pick up, this would not prevent its operation as a motor, as the battery voltage will easily force enough current through the brushes to cause the armature to revolve. If there is nothing wrong with either the field winding or the armature, the generator should turn over at about the lowest speed at which it will charge the battery when driven by the engine—just a trifle lower than this.

PART IV

Testing Out Complete Circuits

If an ammeter is available and the tester has any data regarding the normal performance of the system under test, it can be used to advantage in locating the fault. Most makers of electrical equipment issue and publish in their catalogs, or instruction books, so-called generator output or charging curves, showing the number of amperes the generator will send into the battery at different speeds of revolution. If such a curve is at hand, or if the normal charging rate at a definite generator speed is known, the ammeter can be used to determine whether the generator is delivering its proper charging current. Inasmuch as the charging current with most systems above a certain minimum generator speed is substantially constant, it does not matter very much at what generator speed the reading is taken, provided it is above the minimum speed referred to. This minimum speed of the generator at which charging begins corresponds to a certain car speed on the high gear, usually about 7 or 8 m.p.h., and the tester may be able to tell from the sound of the engine whether it is running at a speed above that at which charging begins. The charging circuit then is opened at the battery and the ammeter is inserted in the circuit at this point. All lamps are turned off. A reading then is taken of the charging current, and if it agrees with the generator output diagrams, there is nothing the matter with the generator, its control mechanism and wiring.

In that case, the trouble, if the battery will not hold its charge, must be in the distributing circuits or in the battery itself. A similar test can be made of the lamp load. Generally the current consumed with all the lights turned on is given in the descriptive matter of the equipment makers. If it cannot be found, it can be calculated fairly accurately from the voltage and candlepower of the lamp.

Supposing the lighting equipment to operate at 6 volts and the lamps to be of the tungsten filament vacuum type, the headlamps will consume each about 1/6 ampere per candlepower and the small lamps about 1/5 ampere per candlepower.

Thus if there are two 15-candlepower headlights, two 4-candlepower side lamps and one each 2-candlepower tail and dashlamp, the total current consumption when all are turned on should be 7.4 amperes. If the current consumption is greater, it may be due to bulbs of high candlepower being used by mistake or to a short-circuit or leak on the line. If the current is smaller than it should be, it may be due to some lamps not burning or to the use of bulbs of too low candlepower or of high-efficiency bulbs. If some lamps are not burning, this may be due to a broken filament, to the bulb being loose in the socket, to a burned-out fuse or to a broken wire or connection.

It is, of course, entirely unnecessary to make a test with instruments requiring disconnections in the circuits, to find out that a lamp does not burn. Usually, if a single lamp fails to light up, it is due either to a broken filament, a bulb loose in the socket or a fuse blown out. If a lamp fails to light up when the switch is closed, see whether it is tight in the socket. If it is not, screwing it home probably will cause it to light up. On the other hand, if it is tight in the socket, the filament probably is broken, which readily is proved by substituting a new bulb known to be in good condition. Often the wire connections at the lamps come loose, and if neither a loose bulb nor a broken filament is found it is well to inspect these connections carefully. In the case of a ground return or single-wire system, with all the sockets grounded on one side, it is well to test the ground of the faulty lamp by making a connection with a screwdriver or a length of wire from the lamp terminal to ground, a bright part of the frame. If this causes the lamp to light up it shows the ground connection to be faulty.

A frequent cause of failure of lamps to light up is a fuse burned out. Fuses are safety devices inserted in practically all electrical circuits. They are the safety links which give out first in case of excessive currents due to short-circuits or other causes, thus protecting the rest of the circuits against injury. The type of fuse most commonly used in motor car circuits is the so-called cartridge fuse, which consists of a short length of glass tube with brass ferrules at both ends, these ferrules being connected metallically by a lead wire inside the glass tube. The complete fuse is pressed between brass clips on the fuse block. These fuse blocks are located in different positions on different makes of cars, but they always are to be found somewhere. If a fuse is blown due to a short-circuit, as soon as another fuse is inserted it, too,

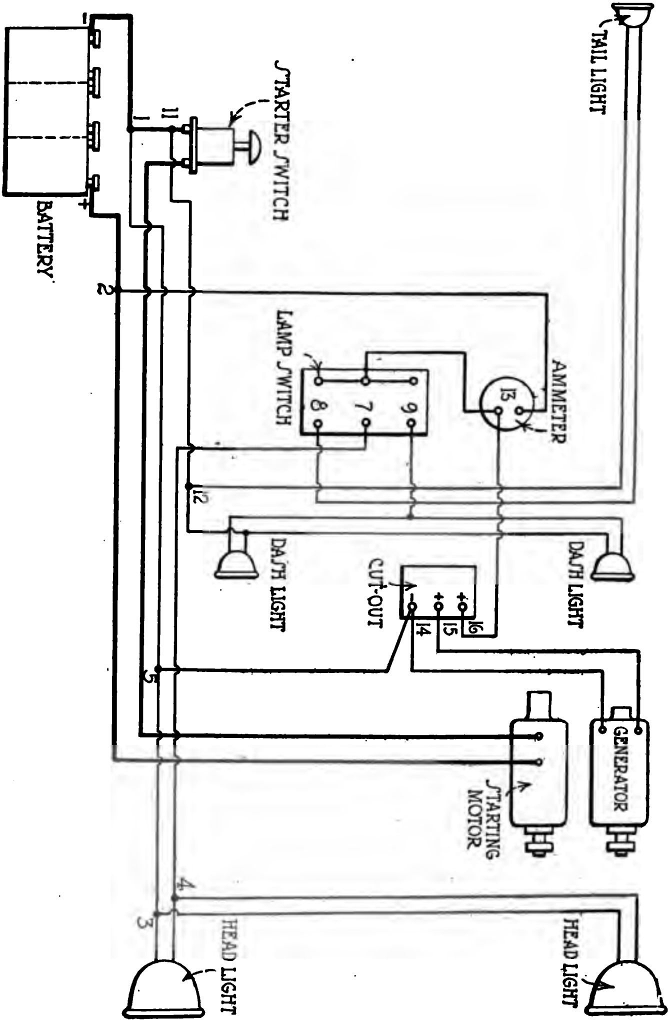


Fig. 345—A typical wiring system

blows. Therefore, before inserting another fuse it is well to test for a short-circuit. Fuses occasionally burn out in regular service or as a result of momentary short-circuits, such, for instance, as occasioned by working on junction blocks, etc., with a screwdriver while the current is on.

The quickest way to test for a blown fuse in a lamp circuit is to turn the lamp switch on and then place the blade of a screwdriver across the fuse clips. If the lamp lights up with the fuse clips bridged by the screwdriver and does not without it, the fuse is burned. If there happened to be a short-circuit on the line, this test will be accompanied by violent sparking at the fuse clips, or, as a repairman would say, by a display of fireworks.

In trying to locate either a ground, an open circuit or a short-circuit in a wiring system it is advisable to divide the system into its various elements or circuits. A typical wiring system is illustrated in Fig. 345. There are only two wires connecting to the battery, and these, therefore, carry all the current that flows into or out of the battery, whether it is charging current or whether it is battery current for starting or for lighting. It will be seen that this is a two-wire, or insulated return, wiring system, and a test for a ground can be made merely by touching test points to any bare part of the wiring and a bright spot on the metallic mass of the chassis respectively.

We will assume now that a general test of the wiring is to be made. Each of the lamp circuits begins at the lamp switch. The headlamp circuit ends at 1, though from 5 to 1 the wire carries both battery current for the headlamps and charging current for the battery—alternately, of course, not simultaneously. To make a test of the headlamp circuit the generating system must be disconnected from it, and this probably can be done best by loosening the connection at the minus terminal of the cutout.

Now with the test points touching the ends of the headlamp circuit at point 7, at the lamp switch and at point 1. If the test lamp lights up or the test bell rings, the headlamp circuit is complete, that is, there is no open circuit. Now remove the bulbs from the headlamp sockets and make another test with the test points in the same way. If current flows, it shows a short in the headlamp circuit. To locate a ground, touch one of the test points to the ends of the headlamp wires, first at 1 and then at 7, while the other test point is connected to ground, that is, some bright spot of the frame, etc. If a signal is obtained, it shows not only a ground in the headlight wiring but also the side of the headlight circuit on which the ground is located.

The tests thus described show any fault in the wiring leading to the two headlamps. If a fault thus is found to exist, it should be attempted to locate it by a careful inspection of the wiring. There is, of course, a possibility of determining by electrical tests still more closely the location of the fault, as by disconnecting the wiring for one lamp from that for the other, at 3 and 4, and testing the wiring for each lamp separately. However, unless absolutely necessary, no permanent joints in the wiring should be opened. Usually the wiring system can be divided sufficiently by undoing the bolted or binding post joints at the switch, junction box, etc. Thus, for instance, if the joint 2 in the diagram is a permanent joint, the circuit can be opened at the ammeter a little farther along the line to the headlamps.

The dashlamp circuit begins at 9 at the lamp switch and ends at 11 on the battery main. The taillight circuit is connected to it at 12, and this connection must be broken if it is desired to make tests of the dashlamp circuit separately. The tests are exactly the same as those for the headlamp circuit and need not be described specially. The tail light circuit begins at 8 at the lamp switch and ends at 12.

That part of the circuit which carries current from the generator to the battery only begins at 2 and ends at 5. This circuit, when the generator is not running, is interrupted in the cutout and if it is desired to make a test of the whole circuit for shorts, breaks, etc., the cutout should be held closed by hand. Also, if 2 and 5 are permanent joints, the tests can be made between 13 and 14.

There remains only the starter circuit to be tested. As a rule, this contains only short lengths of very heavy wire, and it is easier carefully to inspect every part of it than to disconnect it completely from all other circuits and make electrical tests. If the inspection fails to locate the fault, an electric test, however, can be made as a last resort.

In making the different tests described with the aid of a wiring diagram it is well to check off the individual circuits on the diagram as they are tested. In this way one can be much more certain that he has covered every part of the system when the test is ended.

If there is a break somewhere in a circuit, by a test lamp or bell the particular section of the circuit in which the break is located easily can be found. Suppose the circuit has been isolated from the rest of the wiring system. Place one test point on the end of one side of the circuit at the point farthest from the lamp or other consuming device. With the other test point touch the first exposed point on the same side of the circuit toward the consuming device. If the test lamp does not light up, the break is in this section; if it lights up, this section is intact, and the test point should be moved to the next exposed point, and so on all around the circuit. When a point is reached where the test lamp shows no light, the break is in the section between this point and the point touched immediately previously.

Applying this to the charging circuit of the wiring system illustrated in Fig. 345, one test point may be connected to point 5 of the system and the other test point would be touched first to point 14. Probably the test lamp would light up. Next it would be touched to the negative terminal of the generator with say, the same result; next to the positive terminal of the generator with the same result; next to point 15 with the same result; next to point 16, when it would show no current flow. The break in the circuit then would be between points 15 and 16 and probably would be due solely to the open cutout, which is not a fault but a natural condition. In this connection it must be remembered that between points 14 and 15 there are two paths for the current, namely, through the generator and through the shunt coil or fine wire coil of the cutout. Therefore, to make the test conclusive, the wire should be removed from terminal 15 while this terminal is touched —to test the shunt coil of the cutout—and while the test wire is touched to the two terminals of the generator and to the end of the wire removed from 15 respectively.

One test of a faulty starter is as follows: Switch on all the lamps, close the starter switch and observe the behavior of the lamps. If there is no effect on the lamps, it shows that no current, or only a very small current, flows through the starter, so that not enough turning effort to crank the engine could be expected. On the other hand, if the lamps grow appreciably dim as the starter switch is closed, it shows that a heavy current flows into ignition system, in charging the storage battery, etc. In each case the electrical energy delivered by the generator is transformed into some other form of energy. For example, in the ignition system the electrical energy is transformed into heat energy in the spark between the points of the spark plugs which is of sufficient intensity to raise the gas around it to the ignition point and as a result the gas mixture in the cylinder is exploded. In the case of the storage battery, the greater part of the electrical energy delivered by the generator is transformed into chemical energy in the battery and as a result the battery is said to become charged.

The frame of the generator for the F. A. electrical system is made from a piece of wrought iron pipe having an outside diameter of approximately 4.5 inches and an inside diameter of approximately 3.0 inches. The length of the frame is approximately 4.5 inches. The generator has four poles and these are formed by bolting four pole pieces inside the frame by means of flat headed machine screws which pass through the frame and into the pole pieces. The complete generator is shown in Fig. 346. The screws shown at S are the ones holding the pole pieces in place.

Each of the four pole pieces is provided with a single field coil which is wound on a special form, taped and impregnated with insulating varnish and then placed on the field core before the core is bolted in place. The projections from the pole pieces serve to hold the field coils in place after the pole pieces are bolted to the frame or yoke of the machine. The four field coils are connected in series in such a manner that the pole pieces are alternately of north and south polarity around the armature. The connections between the various field coils are soldered and taped with an insulating tape. The resistance of the complete field winding at room temperature is approximately 3.0 ohms.

The general features of the armature are practically the same as used in standard practice. There are 21 slots in the armature core, and 21 segments in the commutator. The winding is made from cotton covered enameled wire which is held in the slots by wedges of insulating material driven in the top of the slots after the winding is in place.

The armature is mounted in suitable ball bearings which in turn are carried by end brackets bolted to the generator frame, as shown in Fig. 346. The front end bracket, that is, the one toward the front end of the car when the generator is mounted on the engine, is a flat iron disk having an outside diameter equal to the outside diameter of the generator frame and a pocket in its center containing the ball bearing for the armature shaft. This flange is fastened to the end of the generator frame by means of six cap screws shown at B. in Fig. 346. There are three threaded holes in the outside face of the flange into which the cap screws used in mounting the generator on the engine housing are screwed.

The rear bracket is a cup shaped piece, and it carries the rear ball bearing and the ring upon which the brushes are mounted. This bracket is fastened to the rear end of the generator frame by means of cap screws shown at F in Fig. 346. There are four openings in the cylindrical portion of this bracket through which the commutator, brushes, wiring and general operation of the generator may be examined. These openings are closed by means of a sheet iron cover which slips over the bracket and is held in place by two small screws, shown at A. in Fig. 346.

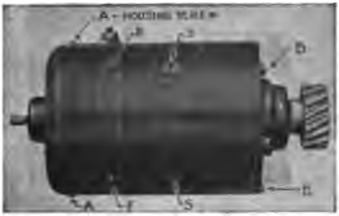


Fig. 346.—F. A. generator.

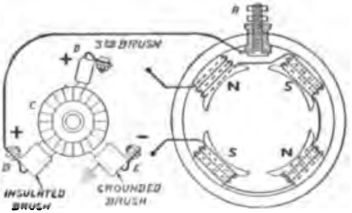
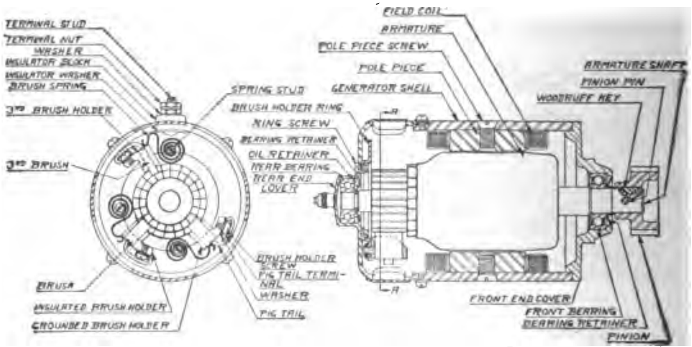


Fig. 347.—F. A. generator circuit diagram.

The armature winding is of the wave type and only two main brushes are required for conducting the current delivered to the external circuit to and from the commutator. These two brushes are mounted on the underside of the commutator as shown diagrammatically in Fig. 347. The upper brush shown in the figure is called the third brush as the output of the generator is controlled by means of the "Third Brush" principle. This third brush is connected to one terminal of the field winding and the other terminal of the field winding is connected to the main brush of negative polarity as shown in the figure. The brush holder for the main negative brush is riveted direct to the metal brush ring which is in electrical contact with the end bracket thus grounding the negative terminal of the generator. The brush holder for the positive brush is mounted on a small strip of insulation and this strip is riveted to the brush ring thus keeping the positive brush from making electrical connection with the frame of the generator. The brush holder for the third brush is mounted on the brush ring in such a manner that it may be moved around the commutator a short distance by first loosening the nut on the bolt supporting the holder and moving the holder to the desired position and then tightening the nut. The bolt holding the brush holder passes through a piece of insulation which is riveted to the brush ring and in which there is a slot cut thus allowing the bolt to be moved a distance around the commutator corresponding to the length of the slot.



CROSS SECTION A-A WITH COVER BAND REMOVED

LONGITUDINAL SECTION OF F.A. GENERATOR

Fig. 348.—*Section and end elevation of generator.*

The main brush ring is fastened to the end bracket by being clamped between a small ring and the end bracket, the small ring being drawn against the end bracket by means of four screws which pass through the bracket from the outside through notches in the brush ring and into the small clamping ring. The notches in the main brush ring permits the ring being moved around the commutator a short distance so as to take care of brush adjustment.

All three of the brushes are of carbon, the two main ones are approximately ⅜-inch by ¾-inch by ¾-inch and the third brush

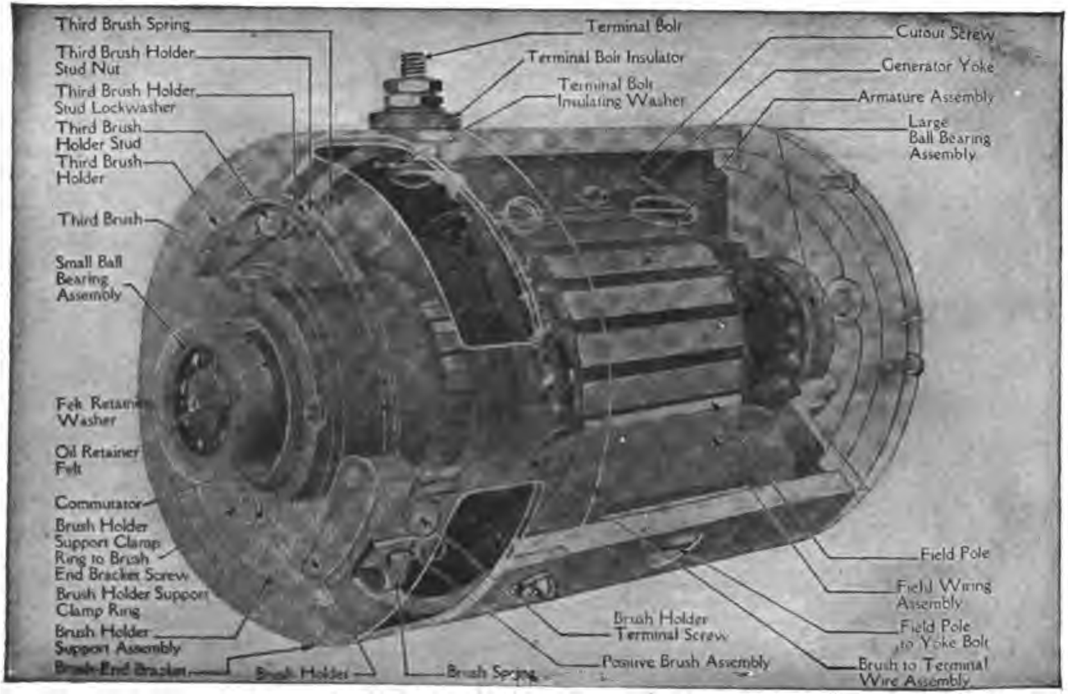

Third Brush Spring
Third Brush Holder Stud Nut
Third Brush Holder Stud Lockwasher
Third Brush Holder Stud
Third Brush Holder
Third Brush
Small Ball Bearing Assembly
Felt Retainer Washer
Oil Retainer Felt
Commutator
Brush Holder Support Clamp Ring to Brush End Bracket Screw
Brush Holder Support Clamp Ring
Brush Holder Support Assembly
Brush-End Bracket
Brush Holder
Brush Spring
Positive Brush Assembly
Brush Holder Terminal Screw
Terminal Bolt
Terminal Bolt Insulator
Terminal Bolt Insulating Washer
Cutout Screw
Generator Yoke
Armature Assembly
Large Ball Bearing Assembly
Field Pole
Field Wiring Assembly
Field Pole to Yoke Bolt
Brush to Terminal Wire Assembly

Fig. 349.—Phantom view of generator.

is approximately 3/16 inch by ¾-inch by ¾-inch. Electrical connection is made from the brushes to the brush holders by means of flexible copper pigtails which are securely fastened to the brushes and the brush holders. A longitudinal section and a cross section of the generator are shown in Fig. 348.

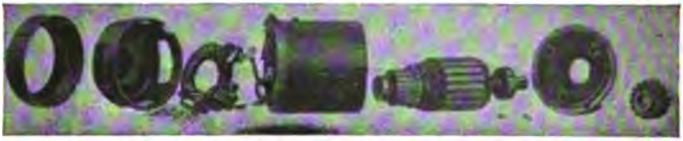


Fig. 350.—Generator in parts.

The brushes are held firmly on the commutator by means of spiral springs made from flat spring steel. One end of each of these springs is mounted in a slot in a stud on the brush holders and the other end bears on the end of the brushes, see Fig. 348. The positive main brush is connected to an insulated terminal on top of the generator as shown diagrammatically in Fig. 347.

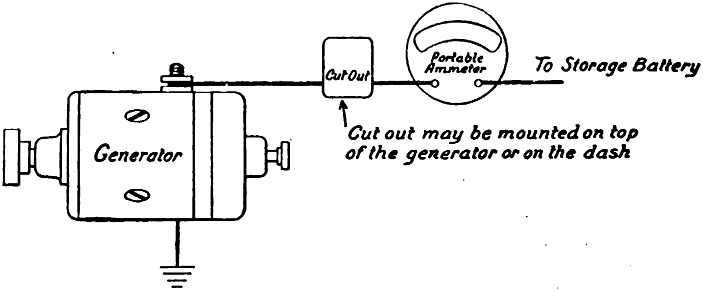

Cut Out
Portable Ammeter
To Storage Battery
Cut out may be mounted on top of the generator or on the dash
Generator

Fig. 351.—Diagram of generator connections.

A phantom view of the complete generator is given in Fig. 349 and all of the principal parts are shown in the exploded view given in Fig. 350.

The generator is installed on the right-hand side of the engine and at the front end. Three cap screws pass through the engine front end cover and into the three holes in the front end bracket of the generator. The joint between the end bracket of the generator and engine cover is provided with a paper gasket to prevent oil leaks.

The generator is driven by means of a pinion mounted on the end of the armature shaft as shown in Figs. 346 and 348, which engages with the large timer gear. There are 16 teeth in the pinion and 24 in the timer gear so the generator runs at one and one half times engine speed.

The relation between engine speed for different gears, miles per hour of the car and generator speed is given in the following table.

Relation Between Engine Speed for Different Gears, Miles per Hour of Car and Generator Speed

Hour of Car	MODEL T			Generator Speed	MODEL TT		
	High	Low	Reverse		High	Slow	Reverse
1	41	112	163	61	76	209	305
2	81	224	325	122	152	419	609
3	122	335	488	183	228	628	914
4	163	447	651	244	305	838	1218
5	203	559	813	305	381	1047	1523
6	244	671	976	365	457	1257	1828
7	285	783	1139	427	533	1466	2132
8	325	895	1301	488	609	1675	
9	366	1006	1464	549	685	1885	
10	407	1118	1627	610	762	2094	
15	610	1677	2440	915	1142		
20	813	2236		1220	1523		
25	1017			1525	1904		
30	1220			1830			
35	1423			2135			
40	1627			2440			
45	1830			2745			
50	2034			3050			

Engine Speed Data

	Model T	Model TT
30 inch diameter wheel, revolution per mile	672.27	
32 inch diameter wheel, revolution per mile		630.25
Gear ratio on high speed	3.63-1	7.25-1
Gear ratio on slow speed	9.98-1	19.93-1
Gear ratio on reverse	14.52-1	29. -1
Revolutions of engine per mile on high speed	2440.34	4569.31
Revolutions of engine per mile on slow speed	6709.25	12565.70
Revolutions of engine per mile on reverse	9761.36	18277.25
MPH of car equals engine speed in RPM on high speed when multiplied by	40.67	76.16
MPH of car equals engine speed in RPM on slow speed when multiplied by	111.82	209.42
MPH of car equals engine speed in RPM on reverse when multiplied by	162.68	304.62
Ratio of crank shaft to drive shaft on slow speed	2.75-1	2.75-1
Ratio of crank shaft to drive shaft on reverse	4.-1	4.-1

The front bearing of the generator is lubricated by means of oil which spashes from the timer gear. The rear bearing is lubricated by oil supplied through a specially constructed oil cup mounted at the end of the bearing, as shown in Fig. 346.

The value of the current delivered by the generator is regulated by means of the ''Third Brush'' system of regulation. The field winding is connected between the third brush which rests upon the upper side of the commutator and the negative main brush which is grounded. The value of the current delivered by the generator may be increased by moving the third brush in the direction of rotation and conversely the current output may be decreased by moving the third brush in the opposite direction to the direction of rotation. It is best to connect an ammeter in the circuit when an adjustment in the current delivered by the generator is being made. The ammeter may be connected in the main circuit leading from the generator as shown diagrammatically in Fig. 351. Before attempting to make any adjustment in the value of the current delivered by the generator be sure that the commutator is in good condition, that the brushes are making good electrical contact with the commutator, that all connections in the generator circuit are O. K. particularly the cutout contacts, battery connections and the ground connection from the battery. The voltage of the battery should be normal, that is, there should be no broken down cells or high-resistance cells in the battery. Assuming the electrical circuit is in first class condition, with the exception of the position of the third brush, then you may proceed as follows: Run the engine at approximately 800 revolutions per minute and move the third brush to the position giving the desired value of current. The engine should then be run at different speeds so as to be sure that the value of the current does not exceed the allowable value. It is advisable to sandpaper the undersurface of the third brush after the brush has been placed in its final position and a final check made on the generator outfit.

The third-brush system of control causes the current output of the generator to increase up to a certain speed and then the current output starts to decrease in value. The speed of the F. A. generator for maximum current output is approximately 1200 revolutions per minute which corresponds to a car speed in high gear of approximately 20 miles per hour. A maximum charging current of 10 to 12 amperes will meet the average driving conditions.

(b) THE STORAGE BATTERY

The storage battery is composed of three cells and is known commercially as a six-volt sixty-ampere hour battery. The larger part of the electrical energy delivered by the generator is stored in the storage battery in the form of chemical energy which is retransformed into electrical energy when the battery is called upon to operate the starting motor, ignition system, lamps, etc.

In the earlier installations the storage battery was mounted in a box on the left running board, while in later cars the battery is under the left rear floor boards. It is carried in a frame made from flat iron bars, and held down by two flat pieces which press down on the wooden containing case at the ends, the pieces being held in place by thumb screws.

(c) CUTOUT

The connection between the generator and the storage battery cannot be a permanent one as the storage battery would discharge through the armature of the generator whenever the electrical pressure in the armature of the generator happened to be less than the electrical pressure of the battery. The discharge current from the storage battery will increase in value as the electrical pressure of the generator decreases in value. When the generator armature is standing still there is no electrical pressure induced in the winding and the discharge current from the battery through the generator will have its maximum value. A device called the cutout is introduced in the circuit connecting the generator and the storage battery whose function is to prevent the needless discharge of the battery under the conditions described above.

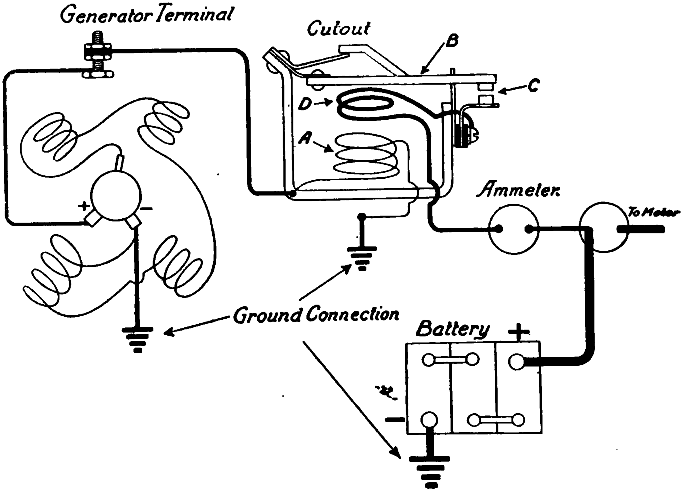
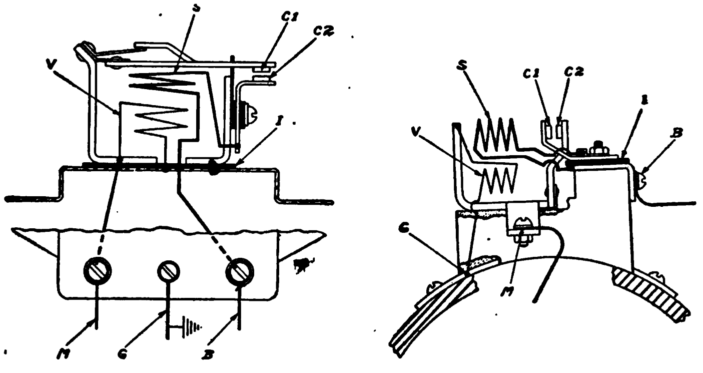


Fig. 352.—*Complete circuit diagram, including cut-out circuits.*

The operation of the cutout can be understood by tracing the circuits as shown diagrammatically in Fig. 352. The winding A of the cutout is called the shunt or voltage winding as it is connected across the terminals of the generator and its circuit may be traced as follows: Starting with the positive terminal of he generator you can trace along the main lead to the frame of the cutout, then through the winding A to the ground connection, then through the ground to the negative terminal of the generator and through the armature winding to the positive terminal thus completing the electrical circuit. As the voltage generated in the armature increases in value, there will be an increase in the value of the current in the winding A. The current in the winding A produces a magnetic pull on the armature of the cutout and when this pull has reached a value sufficient to overcome the action of the spring holding the armature away from the iron core of the cutout the armature will move toward the core and as a result the contacts at C will close. As soon as the contacts at C close a second circuit will be completed from the positive terminal of the generator through the winding D on the cutout, through the ammeter to the positive terminal of the battery, through the battery to the negative terminal of the generator, through the armature winding of the generator to the psitive terminal thus completing the circuit. The current will flow in the above circuit in the direction that the circuit was traced through provided the voltage of the generator exceeds the voltage of the storage battery. The adjustment of the spring holding the armature of the cutout away from the core may be made in such a manner that the armature of the cutout is not drawn down and the contacts C closed until the voltage of the generator exceeds the voltage of the battery. The connections of the windings A and D are such that they both produce magnetizing actions in the same directions while the generator is charging the battery. The pull on the armature is therefore increased as soon as the contacts at C are closed due to the pull produced by the charging current passing through the series winding D, and in



Figs. 353 and 354.—Two types of automatic cut-out in diagram.

addition the pull is further increased due to the fact that as soon as the armature moves nearer the iron core of the cutout the air gap is decreased and the same current in the windings will produce a greater magnetic effect. Now if the pressure of the generator decreases in value there will be a decrease in the current in both of the windings A and D. When the generator pressure is exactly equal to the pressure of the battery there will be no current in the winding D. There will be a smaller current in the winding A than was originally required to close the cutout, but due to the smaller air gap the smaller current in the winding A will keep the contacts closed. A further decrease in generator pressure results in the battery starting to discharge and also a slight decrease in the value of the current in the winding A. The currents in the two windings are now producing magnetizing actions in the opposite directions and finally the magnetic pull on the armature is no longer ample to overcome the action of the spring tending to draw the armature away, and, as a result, the armature moves away and the contacts at C are separated thus disconnecting the battery from the generator. A larger current will be required in the winding A to again draw the armature over and as a result the contacts will remain separated until the voltage of the generator has built up to a sufficient value so that it produces enough current in the winding A to draw the armature over and close the contacts at C.

Two different types of cutouts have been used with the F. A. system. On a great many cars the cutout is mounted on the engine side of the dash board and on the right side. There are three terminals on the base of the cutout as shown in Fig. 353. The two outside terminals are insulated from the base and they are marked ''Gen.'' and ''Bat.'' respectively. The middle contact is not marked but it corresponds to the ground connection. In mounting the cutout on the car it is grounded to an iron strip projecting up from the frame of the car.

The second type of cutout is mounted on top of the generator housing as shown diagrammatically in Fig. 354. The electrical circuits of the cutout are identical to those shown in Fig. 352, the only difference in the two being in their mechanical construction and arrangement.

CHAPTER XXX

F. A. Starting and Lighting System for Ford Cars

A LARGE percentage of the Ford cars are at the present time being equipped at the factory wih a specially designed starting and lighting system. This system has been developed to meet the particular requirements of the Ford car and the necessary changes in the engine housing have been made by the Ford Co. so as to accommodate the system in the best way possible. The system is known commercially as the F. A. Starting and Lighting System, the initials being those of the engineer designing the system.

Component Parts of the F. A. Starting and Lighting System

(a) Generator
(b) Storage Battery
(c) Cutout
(d) Ammeter
(e) Starting Motor
(f) Starting Switch
(g) Lamps
(h) Combination Switch
(i) Connecting Leads

Function and Description of Each of the Component Parts of the F. A. Electrical System

(a) THE GENERATOR

The generator is a machine for converting mechanical energy into electrical energy. The mechanical energy is produced by the gas engine and it is in turn transferred to the generator through a suitable train of gears, chain, belt or other suitable mechanical connecting link. The electrical energy delivered by the generator may be used in operating the lamps on the car, in operating the

The dimensions of the frame and end brackets of the F. A. starting motor are practically the same as those of the generator which has been fully described. The chief difference is in the construction of the end bracket at the drive end of the motor. This bracket is fastened to the frame of the motor by six cap screws. A side view of the complete starting motor is shown in Fig. 356.

The armature has 21 slots and there are 21 segments in the commutator.

Ball bearings are not used in the construction of the starting motor. The front bearing is made from a brass or bronze bushing and the back bearing is made from a bushing of soft bearing metal. The bearing next to the flywheel is lubricated by oil splashed from the flywheel and the other bearing is not lubricated at all.

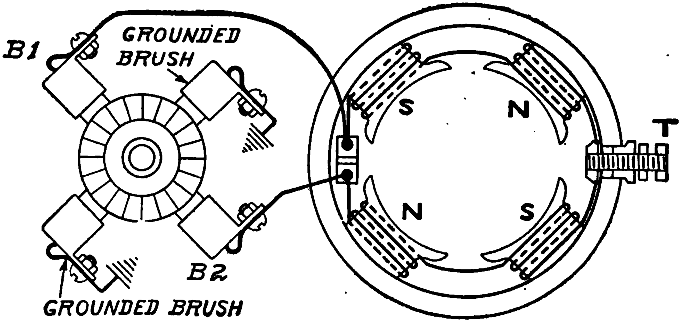
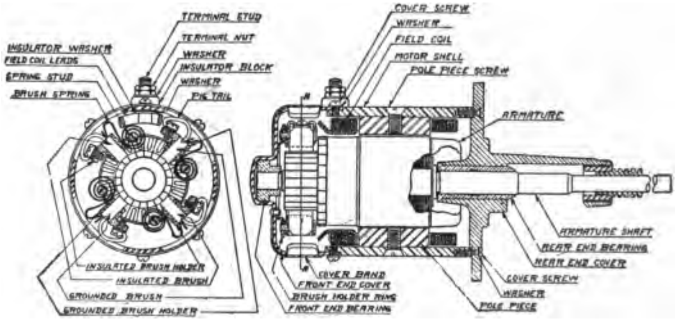


Fig. 357.—Circuit diagram of starter.

Each of the four field poles carries a heavy field coil and these field coils are connected in series as shown diagrammatically in Fig. 357. There is not insulation on the joints between the field coils and care should be exercised to see that the bare copper does not come into contact with the motor frame when repairs are being made on the motor. The motor is of the series type, that is the field windings are connected in series with the armature. Instead of all four coils being connected in series in a single circuit they are grouped in two circuits of two coils each. Each of the positive brushes of the motor, there being two, is connected to one terminal of each of these groups and the remaining terminals are both connected to the insulated terminal on top of the motor as shown in Fig. 357.

The motor is provided with four composition brushes arranged as shown diagrammatically in Fig. 357. These brushes are each approximately ⅜-inch by ¾-inch by ¾-inch. The two negative brushes are mounted in brush holders which are riveted direct to the brush ring and are therefore grounded to the frame of the motor as the brush ring is not insulated from the frame of the motor. The two positive brushes are mounted in brush holders which are insulated from the brush ring by mounting them on small strips of insulation which are in turn riveted to the brush ring. The brushes are electrically connected to their holders by means of two heavy copper pigtails. The brush springs are very similar to those used on the generator. They are of the spiral type and made from flat spring steel, one end is fastened in a slotted stud which is part of the brush holders and the other or free end rests on top of the end of the brush.



CROSS SECTION A-A

LONGITUDINAL SECTION OF F.A. STARTER

Fig. 358.—End elevation and section of starter.

The metal ring upon which the brush holders is mounted is riveted to the end bracket or housing of the motor by means of four rivets and the brushes cannot be moved.

A longitudinal and cross-section of the F. A. motor are shown in Fig. 358. The arrangement of the brushes, brush holders, etc. are quite clearly shown in this figure. A phantom view of the

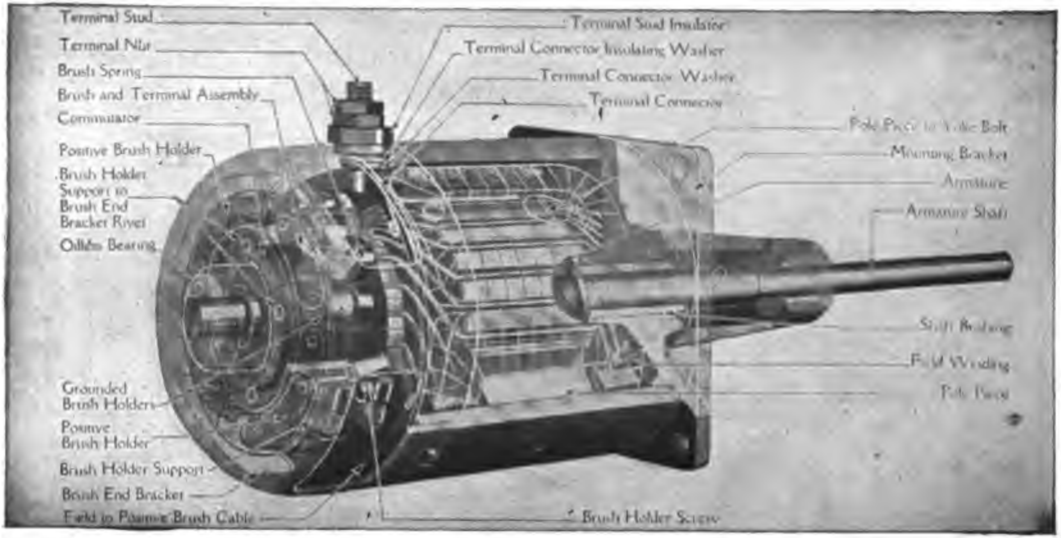


Fig. 359.—Phantom view of starter.

motor shown in Fig. 359, and an exploded view of the various parts is shown in Fig. 360.

The starting motor is located on the left-hand side of the engine and at the rear. It is fastened to the flywheel cover by means of four bolts which pass through holes in the corners of the back end bracket. The power produced by the motor is transmitted to the egine by means of a Bendix drive pinion which meshes with a ring gear mounted on the flywheel of the engine. A cut-away view of the Bendix drive is shown in Fig. 361. The drive pinion is mounted on a hollow screw shaft, and it will move along this shaft if it is held from turning and the shaft is rotated. When a current is established in the armature and field windings of the starting motor its armature will start to revolve. The rotation of the armature shaft causes the hollow screw shaft to rotate as it is connected to the end of the armature shaft by means of the drive spring one end of which is attached to the drive head and the other end is connected to the screw shaft. The weight and inertia of the pinion tends to prevent its turning with the hollow screw shaft and as a result it moves lengthwise along the screw shaft and becomes engaged with the teeth in the ring gear on the flywheel. When the pinion meshes with the ring gear it continues to move along the screw shaft, until it comes into contact with the stop nut and then starts to turn the ring gear and crank the engine. When the engine starts under its own power, it, of course, runs faster than it was being cranked by the starting motor and the pinion on the screw shaft is driven faster than the screw shaft is turning. As a result the pinion moves lengthwise along the screw shaft until it is out of mesh with the gear on the fly wheel. The peculiar construction of the device causes the pinion to clutch the threaded shaft and it then rotates with the threaded shaft until the armature of the starting motor

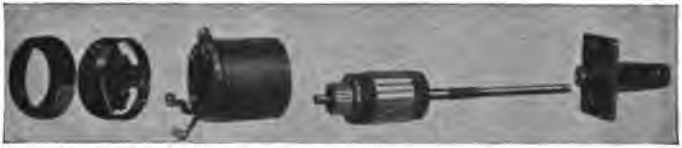


Fig. 360.—F. A. starter in parts.

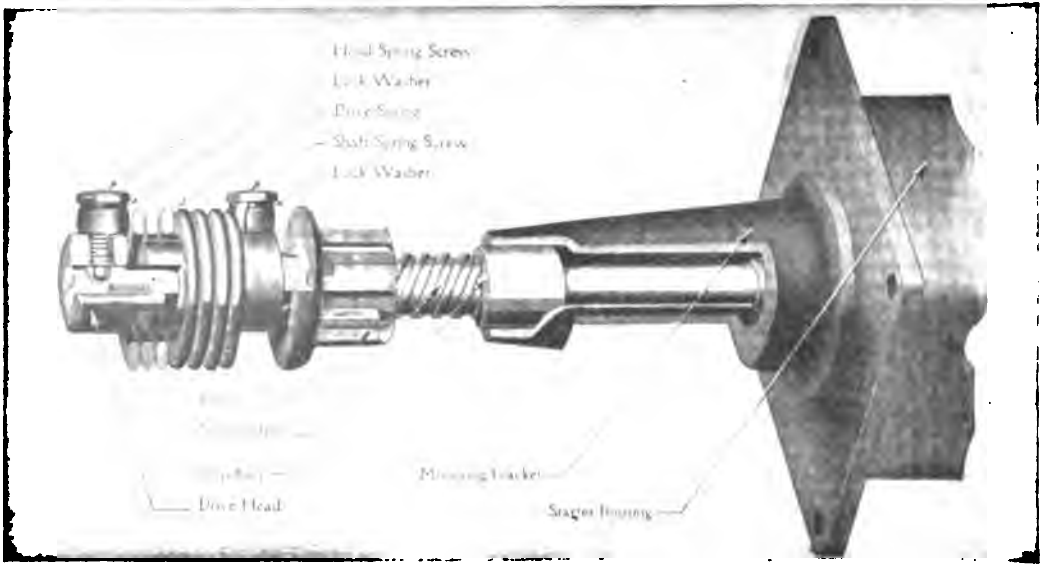


Fig. 361.—Bendix drive of F. A. starter.

ceases to rotate, due to the opening of the electrical circuit supplying it with current.

By reference to the view shown in Fig. 361, and the above description it is seen that the driving torque of the armature is transmitted to the driving pinion by means of a torsion or drive spring, which not only cushions the blow in starting the cranking of the engine, but also stores up some energy due to the running start while the gears are meshing, and then returns this energy in actually breaking the engine loose. The most difficult part of cranking an engine, especially in cold weather, is starting the engine to rotate from stand-still.

Should the driver accidently close the starting motor circuit while the engine is running no harm will result, as the pinion will rotate on the hollow threaded shaft until it touches the edge of the flywheel when it will immediately rotate in the direction of the threaded shaft but a little faster thus carrying it along the threaded shaft away from the flywheel in exactly the same manner as thought it was being demeshed by the engine's starting.

Fig. 362.—*Starter switch.*

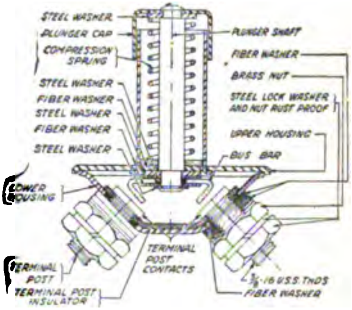


Fig. 363.—*Section of switch.*

The various parts of the drive are made with large factors of safety so as to take care of the unusual strains they will be subjected to in the case of a backfire. Such an occurrence is not likely to happen, but it is advisable to protect the starting system by retarding the spark when starting.

There are 10 teeth on the motor pinion and 120 on the flywheel, which results in the motor running twelve times as fast as the engine.

(f) STARTING SWITCH

The function of the starting switch is to provide a convenient means of connecting the starting motor to the storage battery when it is desired to have the starting motor crank the engine. The switch is mounted on the floor board in front of the driver's seat in such a position that it may be operated by the heel of the driver's right foot. The main body of the switch is on the underside of the floor board and it is operated by a round plunger which extends vertically through a hole in the floor board and projects a short distance above the upper surface of the board. The switch is closed by pushing down on the plunger with the heel. A view of the completed switch is shown in Fig. 362, and a cross section is shown in Fig. 363. The switch is held in the open position by means of a compression spring, which also serves to open the switch when the heel is removed from the plunger cap.

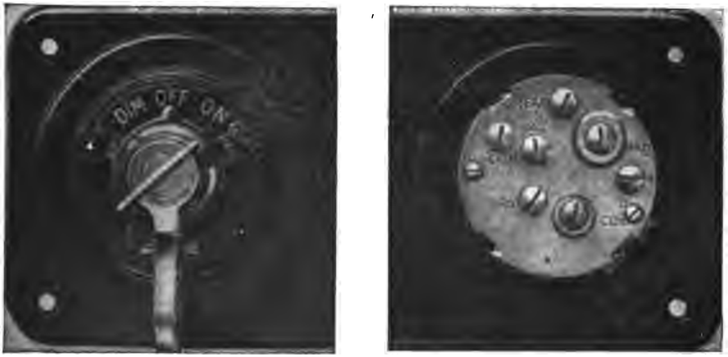
The detailed construction of the switch is quite clearly shown in Fig. 363. The main housing is made in two parts which are held together by two flat headed screws. Two contact terminals are secured to the lower half of the housing and they form the main terminals of the switch. These two contact-terminals are connected together electrical when the switch is closed by a short metal bus bar mounted on the lower end of the plunger shaft.

(g) LAMPS

Each of the two headlamps is equipped with two lamp sockets. The bright headlights are 6-8 volt, 17 candle power bulbs and they are mounted in sockets in the center of the reflectors. The dim headlights are 6-8 volt, 2-candle power bulbs and they are mounted in lamp sockets in the upper half of the reflector. The tail lamp is 6-8 volt, 2-candle power bulb. There is no cowl or dash lamp. The lamps are controlled by means of a switch mounted on the dash of the car within easy reach of the driver.

(h) COMBINATION SWITCH

The current for operating the lamps and the ignition system is controlled by what is called a combination switch which is located on a small panel alongside the ammeter and the combination is mounted on the dash or cowl board of the car. The switch is so constructed and wired that current for the lamps is drawn from the battery when the engine is idle, and partly from the battery when the engine is operating and the generator is delivering current until the value of the current delivered by the generator exceed that taken by the lamps and the ignition system, if the ignition key is thrown to the battery position, and then the generator is taking care of the lamps and ignition and also charging the battery. Current for opening the ignition system may be taken from the battery or from the magneto. A front view of the switch is shown in Fig. 364.



Figs. 364 *and* 365.—*Front and rear view of lighting and ignition switch.*

The lights are controlled by turning the switch lever so that the pointer registers with the indication of the condition as desired; "Off," meaning no lights; "Dim," meaning dim lights; and "On" meaning bright lights. The tail light burns when the lever is in either the "On" or "Dim" positions.

The ignition circuit is controlled by inserting a key in the barrel of the level and turning the key so its position registers with the indication of the source of current desired. The key is shown in the magneto position in Fig. 364, meaning that the ignition current is being supplied by the magneto.

The terminals on the back of the switch are marked to indicate which wires should be attached to them. A rear view of the switch is shown in Fig. 365.

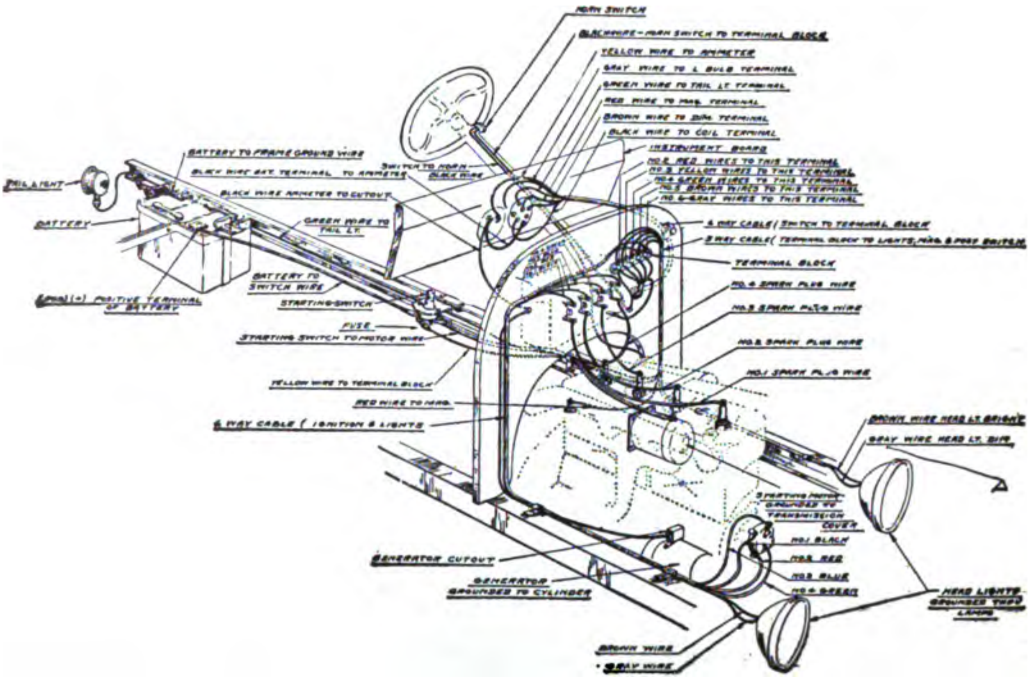

HORN SWITCH
BLACK WIRE–HORN SWITCH TO TERMINAL BLOCK
YELLOW WIRE TO AMMETER
GRAY WIRE TO L BULB TERMINAL
GREEN WIRE TO TAIL LT TERMINAL
RED WIRE TO MAG. TERMINAL
BROWN WIRE TO DIM. TERMINAL
BLACK WIRE TO COIL TERMINAL
INSTRUMENT BOARD
NO. 2 RED WIRES TO THIS TERMINAL
NO. 3 YELLOW WIRES TO THIS TERMINAL
NO. 4 GREEN WIRES TO THIS TERMINAL
NO. 5 BROWN WIRES TO THIS TERMINAL
NO. 6 GRAY WIRES TO THIS TERMINAL
4 WAY CABLE (SWITCH TO TERMINAL BLOCK
5 WAY CABLE (TERMINAL BLOCK TO LIGHTS, MAG. & POST SWITCH
TERMINAL BLOCK
NO. 4 SPARK PLUG WIRE
NO. 3 SPARK PLUG WIRE
NO. 2 SPARK PLUG WIRE
NO. 1 SPARK PLUG WIRE
BROWN WIRE HEAD LT. BRIGHT
GRAY WIRE HEAD LT. DIM
STARTING MOTOR GROUNDED TO TRANSMISSION COVER
NO. 1 BLACK
NO. 2 RED
NO. 3 BLUE
NO. 4 GREEN
HEAD LIGHTS GROUNDED THRU LAMPS
BROWN WIRE
GRAY WIRE
TAIL LIGHT
BATTERY
GRND (+) POSITIVE TERMINAL OF BATTERY
BATTERY TO FRAME GROUND WIRE
BLACK WIRE BAT. TERMINAL TO AMMETER
SWITCH TO HORN BLACK WIRE
BLACK WIRE AMMETER TO CUTOUT
GREEN WIRE TO TAIL LT.
BATTERY TO SWITCH WIRE
STARTING SWITCH
FUSE
STARTING SWITCH TO MOTOR WIRE
YELLOW WIRE TO TERMINAL BLOCK
RED WIRE TO MAG.
6 WAY CABLE (IGNITION & LIGHTS
GENERATOR CUTOUT
GENERATOR GROUNDED TO CYLINDER

Fig. 366.—F. A, Ford wiring diagram.

(i) Connecting Leads or Wiring

A complete wiring diagram is shown in Fig. 366. A very heavy cable leads from the positive terminal of the battery to one terminal of the starting switch and is marked in the figure battery to switch wire. A second heavy cable leads from the remaining terminal of the starting switch to the insulated terminal on top of the starting motor, and is marked in the figure starting switch to motor wire. Another heavy short cable connects the negative terminal of the battery to the frame of the car and is marked in the figure battery to frame ground wire.

Fig. 367.—*Terminal block.*

A multiple conductor cable composed of five conductors leads from the terminal block on the front side of the dash to the lights, magneto and foot switch. A view of the terminal block is shown in Fig. 367. The five wires in this cable have different colored insulations and they make the following connections. The red wire is connected to the left-hand binding post on the terminal block and leads to the magneto terminal. The yellow wire is connected to the second binding post on the terminal block and leads to the starting switch terminal. The green wire is connected to the third binding post on the terminal block and leads to the tail lamp. The brown wire is connected to the fourth binding post on the terminal block and leads to the large lamp in the left-hand headlight. The gray wire is connected to the fifth binding post on the terminal block and leads to the small lamp in the left-hand headlight.

The following connections are made by means of a six conductor cable from the instrument board to the terminal block and the ignition coil. The red wire is connected from the terminal on the back of the combination switch marked "Mag" to the left-hand binding post on the terminal block. The yellow wire connects from one terminal on the ammeter to the second binding post on the terminal block. The green wire is connected from the terminal on the back of the combination switch marked "Rear" to the third binding post on the terminal block. The brown wire is connected from the terminal on the back of the combination switch marked "D" to the fourth binding post on the terminal block. The gray wire connects from the terminal on the back of the combination switch marked "L heads" to the fifth binding post on the terminal block. The black wire connects from the terminal on the back of the combination switch marked "Coil" to the common terminal of the four ignition coils.

Another six conductor cable makes the following connections. The black, red, blue and green wires connect from the distributor to the four terminals of the ignition coils. The brown wire connects from the fourth binding post on the terminal block to the large lamp in the right-hand headlamp. The gray wire connects from the fifth binding post on the terminal block to the small lamp in the right-hand headlamp.

A single black wire leads from the terminal on the cutout to one of the terminals on the back of the ammeter and from this same terminal on the ammeter the connection is extended by a piece of black wire to the terminal on the back of the combination switch marked "Bat."

A black wire connects from the first binding post on the terminal block to the horn switch, and another black wire connects from the horn switch to the horn.

Four high-tension wires lead from the high-tension terminals of the coils to the spark plugs in the tops of the four cylinders. The cylinders are numbered consecutively from the front end of the engine toward the rear. The firing order is one, three, four, two.

Electrical Circuits

The principal electrical circuits of the F. A. starting and lighting system may be easily traced by reference to the wiring diaterminal of the generator you pass through the cutout contacts, gram shown in Fig. 366.

Charging Circuit: Starting with the positive or undergrounded terminal of the generator you pass through the cutout contacts, when they are closed, along the black wire to one terminal of the ammeter, through the ammeter and along the yellow wire to the second binding post on the terminal block, then along another yellow wire to one terminal of the starting switch, then along the heavy battery to switch cable to the positive terminal of the battery, through the battery to the negative terminal which is grounded to the frame of the car then along the frame of the car to the negative terminal of the generator which is also grounded to the frame of the car, through the armature winding to the positive terminal, thus completing the circuit. If the electrical pressure of the generator exceeds the pressure of the battery a current will flow through the battery from its positive terminal toward its negative terminal and the battery is said to be charging. The value of the charging current will be indicated on the ammeter. This charging operation will continue as long as the generator pressure exceeds the battery pressure and when the generator pressure drops below the battery pressure the circuit will be opened by means of the cutout and it will not be closed again until the generator pressure has increased to a value greater than the battery pressure.

Starting Motor Circuit: Starting with the positive terminal of the storage battery you can trace along the heavy cable to the starting switch, then through the starting switch when it is closed, then along the starting switch to motor cable, through the field windings of the starting motor, through the armature of the starting motor to the grounded terminal or frame of the car, along the frame to the negative terminal of the storage battery which is also grounded, through the storage battery to the positive terminal, thus completing the circuit.

Lighting Circuits: Starting with the positive terminal of the battery you can trace along the heavy battery to switch cable, then through the yellow wire to the second binding post on the terminal block, then through another yellow wire from the second binding post on the terminal block to one terminal of the ammeter, through the ammeter to the battery terminal of the combination switch. Now if the lighting switch is thrown to the position marked "On" the circuit will be completed as follows: from the terminal on the back of the combination switch marked "L head" along the gray wire to the fifth binding post on the connecting block and from this point the circuit divides, a gray wire leading to each of the large bulbs in the head lamps through the bulbs to the frame of the car or ground, then along the frame of the car to the negative terminal of the battery which is also grounded through the battery to the positive terminal thus completing the circuit. If the lighting switch is thrown to the position marked "Dim" the circuit from the combination switch will be completed as follows: from the terminal marked "D" along the brown wire to the fourth binding post on the terminal block, and from this point the circuit divides a brown wire leading to each of the small bulbs in the headlamps, through the bulbs to the frame of the car and the remainder of the circuit is the same as for the large lamps. With the lighting switch in either the "Dim" or "On" positions a circuit through the tail lamp will be established as follows: from the terminal on the back of the combination switch marked "Rear" along the green wire to the third binding post on the terminal block, along another green wire to the tail lamp, through the bulb to the frame of the car, or ground, back to the negative terminal of the battery, through the battery to the positive terminal of the battery thus completing the circuit.

Battery Ignition Circuit: Current for ignition purposes will be supplied by the battery when the ignition key is turned into the position marked "Bat" and the circuit may be traced as follows: The circuit from the positive terminal of the battery to the "Bat" connection on the back of the combination switch is the same as for the lights which was traced in the previous paragraph. From the terminal on the back of the combination switch marked "Coil" you can trace along the black wire direct to the coil terminal which is common to one side of each of the four primary windings. The circuit will be completed through each of the four primary windings in regular order by means of the timer which will ground one end of each of the black, red, blue and green wires leading from the primary windings of the coils to the timer. The grounding of each of these wires in turn completes the circuit back to the negative terminal of the battery through the battery to the starting point.

to the first binding post of the terminal block, then along the black

Horn Circuit: From the magneto terminal along the red wire wire to the horn switch, from the horn switch along another black wire to the horn terminal, through the horn winding to the frame of the car and back to the grounded terminal of the magneto.

Maintenance of F. A. Electrical System

The maintenance of the F. A. starting and lighting system may for convenience be divided into the following five groups.

Maintenance of Generator
Maintenance of Motor
Maintenance of Cutout
Maintenance of Storage Battery
Maintenance of the Electric Wiring

Each of these different groups will be discussed in detail in the following paragraphs.

Maintenance of Generator

A general classification of the most likely generator troubles is given in the table entitled Generator Trouble Chart. It will be observed that all of the generator troubles are classified as being either mechanical or electrical and they will be discussed according to this classification.

GENERATOR MECHANICAL TROUBLES

The mechanical troubles usually experienced in the operation fo the generator are as a rule confined to the following:

(a) Loose Driving Gear
(b) Broken Bearing
(c) Armature off Center
(d) Shaft Bent
(e) Commutator Bursted

Each and every one of the above mechanical troubles can be located by a careful visual inspection of the generator.

(a) For example, take hold of the gear by hand (it is assumed the generator has been removed from the car) and you can easily determine if it is firmly keyed to the shaft.

(b) The armature may be turned by hand to see if it runs freely and noiselessly. If it is found that the armature sticks or turns hard, the bearings should be examined to see if they are broken thus allowing the armature to drag on the pole pieces.

(c) If the armature turns hard or seems to drag it may be off center due to worn bearings, which can be easily determined by observing the freedom of the armature in the bearings, or the drag may be due to a loose pole piece, which is caused by one of the heavy screws holding the pole pieces in place against the inside of the generator frame becoming loosened. The remedy for the trouble, if it is due to worn bearings, is to put in new bearings, and if it is due to a loose pole piece to tighten up the screw holding the pole piece in place. A punch mark should be placed in the outer edge of the screw after it is drawn up tight which will prevent its becoming loosened as easily as it might otherwise.

(d) A bent armature shaft is a somewhat unusual occurrence but it will cause the armature to appear to be out of balance and may even cause it to drag on the pole pieces. It is practically impossible to straighten a shaft and the best and safest remedy is a new armature.

(e) A bursted commutator cannot be repaired and the only remedy is to put in a new one. A bursted commutator will usually be accompanied by considerable other damage such as broken brushes, brush holders, and perhaps the armature winding will be injured. A new armature will doubtless be the cheapest and safest in the end instead of trying to put on a new commutator.

In order to inspect the brushes, which are located at the rear end, it will be necessary to remove the rear end cover band which is held to the end bracket by means of two screws. In order to remove the armature, the brushes must be raised from the commutator by pulling them up in their holders by means of the brush pig-tails. The brushes will be held free from the commutator by means of the brush springs which will press the brushes against the side of the holders. The screws holding the front end bracket should be removed now and the bracket and armature may be completely removed from the frame.

The back end bracket may be removed from the frame by removing the four screws holding it in position and then loosening it from the frame. The short leads connected to the brushes will not permit the end bracket being removed but a short distance from the generator frame and if it is desired to remove it completely the wires and leads will have to be disconnected.

GENERATOR ELECTRICAL TROUBLES

In the outline of generator troubles, there are four-sub-headings to the electrical troubles as follows:

(f) Open Circuits
(g) Short Circuits and Grounds
(h) Third Brush Troubles
(i) Cutout Troubles

(f) Open circuits are more commonly due to a dirty commutator, worn commutator, brushes being stuck, improper or no spring pressure on the brushes, brushes too short or broken, and broken brush connections. Some of the more uncommon causes of open circuits are an open field winding, open armature winding and a broken connection between the commutator and the armature winding proper.

One of the first tests to make on the generator is to operate it as a motor by connecting it direct to a six-volt storage battery with an ammeter in circuit. If the generator does not operate as a motor when it is connected to the battery and there is no reading on the ammeter you know immediately that there is an open circuit If the generator operates slowly as a motor and there is a current of less than five amperes it is an indication that there is a partial open circuit or a poor connection in the generator circuit which does not allow the proper amount of current to flow.

The open circuit may be located by means of the test points by testing the different sections of the circuit through the generator starting from the insulated terminal on top of the frame and continuing to the grounded terminal.

A simple testing outfit for locating opens is shown in Fig. 368. If the test points be applied to the terminals of a circuit or a portion of a circuit and the electrical connection between the points where the test points are applied is complete the circuit through the test lamp will be complete and the lamp will light unless the

Generator Trouble Chart

- Generator troubles
  - Mechanical troubles
    - Broken bearing
    - Loose pinion
    - Loose pole piece
    - Commutator burst
    - Bent shaft
      - Indicated by noise, low current or no current generated
  - Electrical troubles
    - Open circuti
      - Brush rigging
        - Brush connections
        - Brush stuck
        - Brush too short
        - Brush spring broken
        - Dirty commutator
          - Indicated by low current generator or no current at all
      - Armature
        - Intense blue sparking at commutator and flatted commutator bars
      - Fields
        - No current generated
        - If partial open—low current
    - Ground or short circuit
      - Brush rigging
        - Main terminal
        - Brush connections
        - Brush holders
          - Low or no current generated
      - Armature
        - Excessive heating of armature. Insulation burned—low generation
      - Fields
        - Coils heat
        - Low current generated
      - Commutator
        - No current generated or low current
    - Third brush
      - Incorrect setting
      - Brush not sanded in
      - Spring pressure not right
        - Indicated by charging current being too high or too low and not remaining constant at high speed
    - Cut-out
      - Open
        - No current to battery
        - Generator very hot—will burn out generator quickly
      - Closed
        - Battery will discharge back through generator at about 20 amperes when engine is not running. This will discharge battery.

resistance of the circuit between the test points is too high. The test lamp will have full battery voltage applied at its terminals when the test points are connected directly together, while if the test points are connected with a resistance between them the full voltage of the battery will not be applied to the lamp and it may not burn depending upon what voltage is actually applied to its terminals. If the resistance of the circuit being tested and the resistance of the lamp are equal then the voltage of the battery will be divided equally between them.

The connection between the insulated terminal and the positive brush can be tested by applying one of the test points to the terminal and the other one to the brush. If the connection is complete the test lamp will light. The electrical connection between the insulated brush and the commutator may be tested in a similar manner by applying one test point to the brush and the other one to the commutator. The field winding should now be disconnected from the third brush and test made to determine the electrical connection between the third brush and the commutator and also between the grounded brush and the commutator. The field may be tested by applying the test points to its terminals. If the field circuit is open, each coil may be tested separately and the exact one in which the trouble exists determined. An open circuit can thus be localized by means of the above tests and the necessary steps may be taken to remedy the trouble.

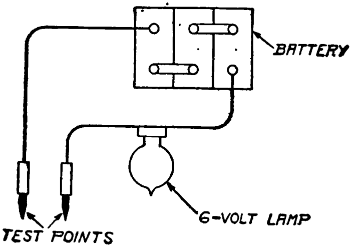


Fig. 368.—Simple testing outfit.

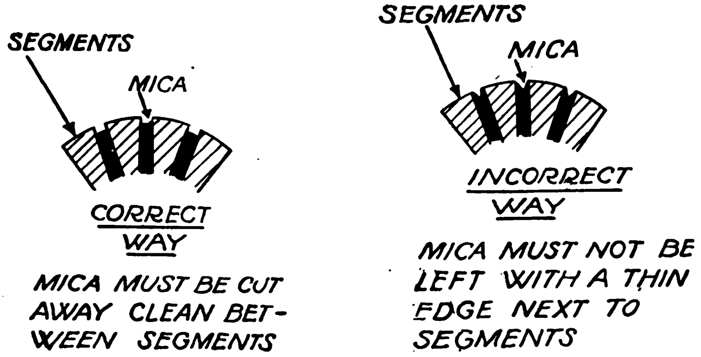
The commutator should be examined to see that it is clean, as a dirty commutator will prevent good electrical contact between the brushes and the commutator bars. If the commutator is dirty due to grease and dirt it may be easily cleaned by using a piece of clean rag moistened in gasoline. A fine pointed piece of hard wood should be used in removing the dirt and grease from between the commutator bars. The mica insulation between the commutator bars is cut away a short distance below the surface of the commutator, or undercut as it is commonly called, which allows the brushes to make better contact with the commutator if the grooves are kept free from all foreign substances.

Quite often a dirty commutator is due to sparking at the brushes, and in such cases it will be necessary to sand it by means of a strip of very fine sand paper preferably not coarser than No. 00. The sand paper should be applied to the commutator by placing it over the end of a piece of wood and then holding the end of the piece of wood against the commutator while the commutator is revolving. The end of the piece of wood should be cut off true so as to prevent grooves being cut in the surface of the commutator.

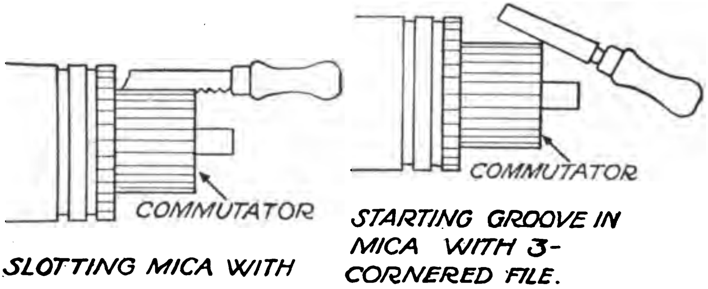
If the surface of the commutator is badly worn so as to allow the mica insulation between the bars to become flush with the surface of the commutator thus preventing the brushes from making good electrical contact with the commutator, there is only one remedy and that is to undercut the mica. The commutator surface should first be trued up by taking a small cut off of it in a lathe and then the mica should be cut away from between the bars to a depth of about 1/32-inch. An end view of the commutator with the mica correctly cut away is shown in Fig. 369, and one in which it is incorrectly cut away is shown in Fig. 370. A convenient tool for cutting away the mica may be made from an old hack saw blade by grinding off the sides of the teeth so that the saw will make a cut the same width as the mica and then providing a suitable handle for it as shown in Fig. 371. The groove in the mica 372, and the saw then used. Be careful in using the saw not to may be started by means of a three-cornered file as shown in Fig. mar the edges of the commutator bars any more than you can help. The rough burs along the edges of the bars should be removed by means of a fine file and the commutator surface well sanded before it is put into service.

An open circuit may be caused by the brushes sticking in their holders and if such is found to be the case the brushes and brush holders should be thoroughly cleaned so that the brushes move freely under the action of the spiral springs pressing them on the surface of the commutator.

An open circuit between the brushes and commutator may be due to not having sufficient spring tension on the brushes so as to hold them in contact with the commutator. Improper spring tension on the brushes will result in sparking at the brushes and a burned and blackened commutator will result which will tend to open the circuit between the commutator and the brushes. A new spring is the best and safest remedy for this job and the commutator and brushes should be thoroughly cleaned. If the spring pressure is too great it has the effect of rapidly wearing out the commutator and the brushes, but is usually considered better practice than too


SEGMENTS
MICA
CORRECT WAY
MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS
SEGMENTS
MICA
INCORRECT WAY
MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS

Figs. 369 *and* 370.—*Right and wrong way of undercutting mica in commutator.*



Figs. 371 *and* 372.—*Slotting commutator with sawblade and starting cut with three cornered file.*

little spring pressure. The spring pressure should be sufficient to snap the brush back on the commutator when it is raised by pulling on the pig-tail and then released.

An open circuit may be caused by the brushes being worn to such an extent the springs will not cause them to make electrical contact with the surface of the commutator. The only remedy for a condition of this kind is to replace the old brushes with new ones. The new brushes should be sanded in as shown in Figs. 373, 374, and 375. Figs. 373 and 374 show two methods of sanding in the third brush while Fig. 375 shows the correct method of sanding in the two lower or main brushes and Fig. 376 shows the incorrect method of sanding in the third brush. The arc of contact between the brushes and the commutator should correspond to the full width of the brush.

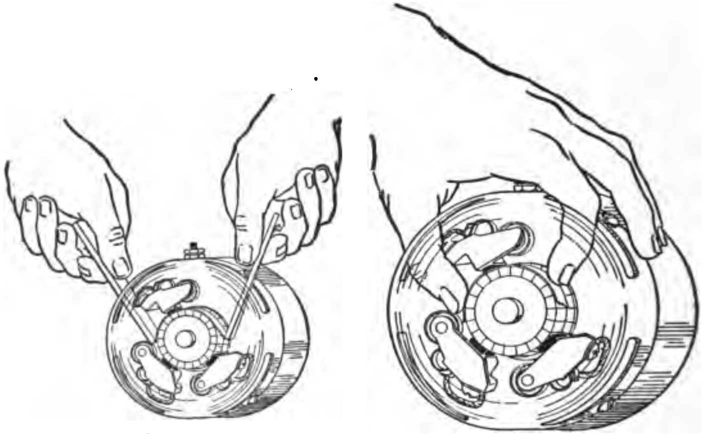


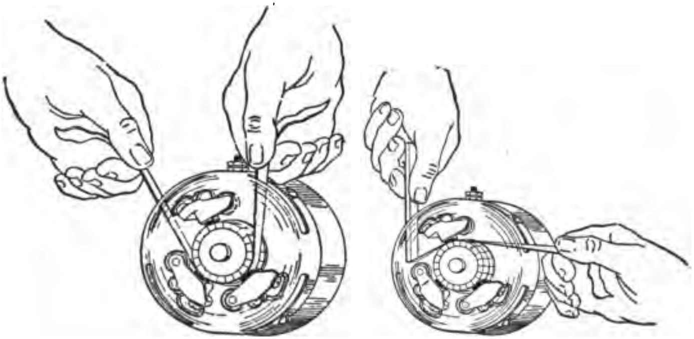
Fig. 204

Fig. 205

Figs. 373 *and* 374.—*Two methods of "sanding in" third brush.*

The pig-tail connection from the brush to the brush holder may be broken or the connections may be loose or broken and in such cases there will be an open circuit from the brush to the brush holder or the circuit will be of comparatively high resistance.

An open circuit in the armature winding will cause excessive sparking at the commutator and several of the commutator bars will be blackened and perhaps burned due to the sparking. A very simple and effective test for locating open circuits in an armature winding is shown diagrammatically in Fig. 377. An ammeter, one cell of a storage battery and the test points are connected in series. The test points are applied to adjacent commutator bars all the way around the commutator and the ammeter reading for each combination is carefully observed. In Fig. 377 the test points are connected to the commutator and the armature shaft which is correct for the ground test. If the ammeter readings are all the same there are no open circuits in the armature winding, but if one or more readings of the ammeter differ from the others to any extent there is an open circuit. The open may be a broken wire leading to the commutator, or the wire may have come unsoldered from the commutator and a careful inspection of the armature will enable you to determine if either of these conditions is the cause of the trouble. If the trouble proves to be within the armature winding, the complete winding will no doubt have to be removed, and it will no doubt be cheaper to put in a new armature than to attempt to rewind the old one, unless it is an extreme emergency.



Figs. 375 *and* 376.—*Correct and incorrect method of "sanding in" main brushes.*

(g) Assuming all of the mechanical difficulties have been corrected and that the generator will not run as a motor when it is connected to the storage battery but a reading of four or five amperes is indicated on the ammeter connected in circuit, or if the generator runs very slowly as a motor and draws more current **than it should, it is an indication that the current is not actually** passing through the armature and field windings in the proper way but a portion or all of it is being shunted through a short or grounded connection and is thus not effective in the operation of the generator as a motor. The more common causes of this kind of trouble are grounded brushes and grounded main generator terminal, and some of the more uncommon causes are grounded commutator, grounded armature winding, grounded field coils and short circuited armature or field coils.

The insulation between the main generator terminal and the frame of the generator may be tested by first disconnecting the lead from this terminal to the positive brush from the positive brush holder and then apply one of the test points to the terminal and one to the frame of the generator. If there is no indication on the ammeter the terminal is insulated from the frame. If the ammeter shows a reading the terminal insulation is in trouble and a careful inspection should be made of the insulating washers and the insulation on the lead from the terminal to the positive brush. The ground may be due to dirt having collected around the terminal and a thorough cleaning will correct the trouble.

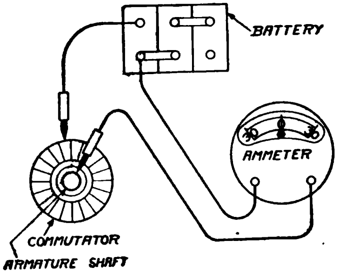


Fig. 377.—*Testing armature for grounds.*

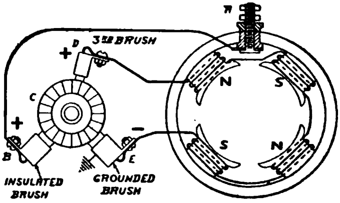


Fig. 378.—*Testing field for grounds.*

The brush holders for the positive and third brushes may be tested for grounds by placing one of the test points on the frame and the other point on the holder, the field connection to the third brush having been removed, and a piece of paper placed between each of the brushes and the commutator. If a ground shows up the trouble is due to dirt or poor insulation and an inspection will determine the exact cause of the trouble. The negative brush holder is grounded permanently and the test does not apply to it.

Both terminals of the field should be disconnected from the brushes as shown in Fig. 378 and then one test point applied to the field and one to the frame of the generator. If the test shows a ground then disconnect the windings from each other and test each of them separately. The field coil found to be in trouble should be removed and the necessary repairs made or a new one substituted. A test should be made after the coil has been put back in place first on the individual coil and then on the entire field after the coils are reconnected. The commutator under normal conditions is insulated from the shaft of the armature and there is no electrical connection between it and the shaft. The commutator may be tested for grounds when it is in the generator by first removing the brushes from the commutator or by placing pieces of paper under them and then applying one of the test points to the commutator and the other to the armature shaft as shown in Fig. 377. If there is no reading on the ammeter it shows that the commutator as well as the armature winding is insulated from the armature shaft and core. If the test shows a ground it may be between the armature winding and the core or between the commutator and the shaft. If the ground cannot be located by a careful inspection, it will be best to replace the defective armature with a new one. A grounded coil may be located by applying one of the test points to each of the commutator segments in regular order and the other test point in contact with the armature shaft, and each of the ammeter readings will be approximately the same for all of the commutator bars. If one of the individual commutator bars or a particular coil is grounded one of the ammeter readings will be larger than the others and this reading will occur when the test point is in contact with the grounded segment or the segment connected to the grounded coil. As stated above, a careful inspection will often locate the trouble.

Short circuited coils may be located in exactly the same manner as that employed in locating open armature coils. If all the ammeter readings are approximately the same the coils are all in good condition, but if one or more of the readings is higher than the average, it is an indication that the coil connected between the two segments on which the test points are placed is short circuited. The increase in current is due to a decrease in resistance caused by one or more of the turns in the coil being cut out of service on account of defective insulation. The exact location of the trouble may be determined by a careful examination of the armature winding.

A short circuit in the field winding may be determined by sending a current through the four coils in series by means of a storage battery as shown diagrammatically in Fig. 379. The resistance of the field winding of the F. A. generator varies from 2.7 to 3.3 ohms depending upon whether the coils are wound with single cotton enameled wire or double cotton covered wire. A six-volt storage battery should produce a current of approximately 2.5 amperes. If the ammeter reading is noticeably larger than this it

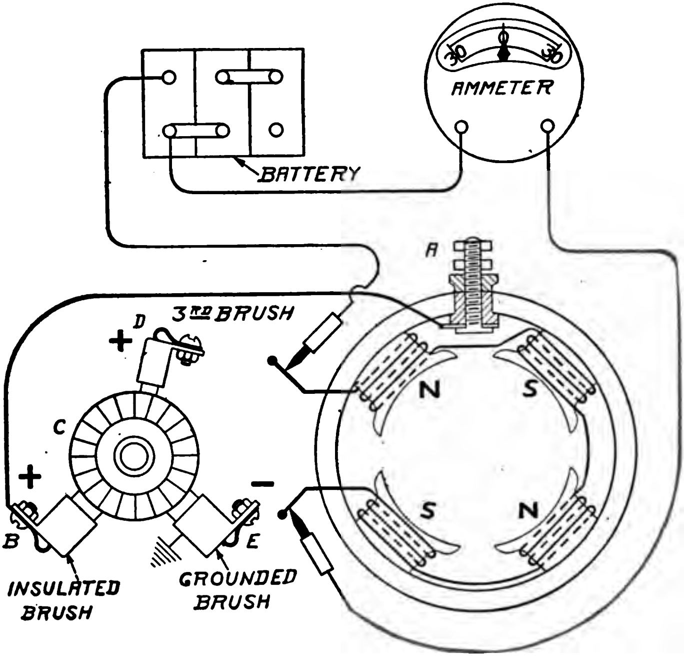


Fig. 379.—Testing field for short circuits.

is an indication that some of the turns in one or more of the field coils are shorted and it is then necessary to determine which ones are defective. The insulation should be removed from the joint between the coils and a test made on each separate coil. The ammeter reading for each separate coil should be the same if they are all in good condition. If any one of the coils show a decidedly higher reading than the others it indicates that a portion of that coil is shorted and not effective in producing a magnetic field. The damaged coil should be removed and repaired or replaced by a new one and the complete winding retested after the coils are all back in place and reconnected.

(h) The operation and adjustment of the third brush has been described in the section on the generator and it is only necessary to mention the fact that the generator output is increased by moving the third brush in the direction of rotation and decreased by moving the third brush in the opposite direction to the direction of rotation of the armature. The contact of the third brush should be as good as possible and the spring pressure sufficient to keep it in firm contact with the commutator.

(i) Cutout troubles are in the majority of cases caused by failure to close and second by failure to open. Failure to close may be due to the voltage or pressure coil being open or short circuited and the contacts may be so dirty that they do not make electrical contact after they are drawn together.

The contact may fail to open due to the points being welded together due to continued opening and closing of the cutout which causes excessive sparking. The spring tension on the armature may not be correct which will cause the cutout to open and close at the wrong time.

The electrical circuits of the cutout may be tested by means of the test points and the contact may be cleaned with a very fine emery cloth or with a very fine jewelers file. The internal circuits of the dash and generator types of cutouts are shown in Figs. 353 and 354.

Maintenance of Motor

Motor troubles are classified the same as generator troubles and a complete chart of these troubles is given for the convenience of the reader.

MOTOR MECHANICAL TROUBLES

The principal mechanical troubles are as follows:

(a) Broken or Worn Bearing
(b) Armature off Center
(c) Shaft Bent.
(d) Commutator Bursted

(a) The bearings on the motor are solid instead of ball bearings as in the case of the generator. The motor runs a very small percentage of the time that the generator is run and for this reason the solid bearings will meet all of the requirements if they are protected by not allowing any dirt to get into them when they are taken out. If upon inspection the bearings are found to be badly worn they should be replaced with new ones. Worn bearings or a badly bent shaft may allow the armature to drag on the pole pieces and cause some serious damage.

(b) The armature may drag and appear to be off center due to one or more of the pole pieces being loose and the remedy for a condition of this kind is to draw the pole piece back in place by tightening the screw which holds it. It is advisable to place a rather deep punch mark in the outer edge of the screw after it is drawn up which will keep it from working loose so easily.

(c) A bent armature shaft is more likely to occur in the operation of the motor than in the case of the generator and especially if the spark lever is advanced to such an extent that the engine "kicks back". It is almost impossible to straighten a bent shaft and the quickest and best way is to put in a new armature.

(d) A bursted commutator usually causes considerable other damage especially to the brushes and brush holders. The best practice is to replace the old armature with a new one as the cost and inconvenience in making the repairs will amount to more than a new armature.

Motor Trouble Chart

- Motor troubles
  - Mechanical troubles
    - Worn bearings
    - Shaft bent
    - Commutator burst
    - Loose pole piece
    - Broken bendix
    - Armature off center
      - All indicated by excessive current draw and slow cranking or complete failure to crank and excessive noise
  - Electrical troubles
    - Open circuit
      - Brush rigging
        - Pigtails
        - Brushes not contacting
          - Brushes too short, poor spring pressure—dirty or burned commutator
            - All indicated by low current or no current and failure to crank. If only partial open occurs the current draw will be low and cranking slow
      - Armature
        - Intense blue spark at brush and flatted commutator with slow cranking
      - Fields
        - No current
        - No cranking
    - Ground or short circuit
      - Fields
        - Excess current
        - Slow cranking
      - Armature
        - Excess current
        - Burnt insulation
        - Slow cranking
      - Commutator
        - Excessive current
        - No cranking
      - Brush rigging
        - Main terminal
        - Brush holders
        - Pigtails and connectors
          - Indicated by excessive current and no cranking, or slow cranking

MOTOR ELECTRICAL TROUBLES

In the outline of motor troubles there are two sub-headings as follows

(e) Open circuits
(f) Short circuits and grounds

(e) Open circuits are more commonly due to dirty commutator, worn commutator, brushes stuck in the holders, improper or no spring pressure, brushes too short or broken, broken brush connections, open field circuit, open armature circuit and a broken connection between the commutator and armature windings. An open circuit in the starting motor may be detected by making a free running test on it with an ammeter in circuit. If the motor fails to run and there is no reading on the ammeter it indicates that the motor circuit is open. If the motor runs very slowly and takes considerably less than 75 amperes it indicates that there is a partial open circuit or a poor connection or contact some place in the motor circuit. The general method of locating open circuits in the case of the motor, except for the armature, is practically the same as in the case of the generator which has already been described in detail. The resistance of the winding of the motor armature is so very low that the method employed in the case of the generator cannot be used satisfactorily for the motor armature. The only place that an open circuit is likely to occur is where the ends of the coils connect to the commutator bars and it can usually be detected by a careful inspection. The wires should be raised from the slot in the commutator riser and thoroughly cleaned, then resolder in place. An open armature coil causes a "flat" to develop due to continuous arcing at that particular spot. The internal connections of the motor are shown diagrammatically in Fig. 357.

(f) If the motor fails to turn or turns very slowly when you are making the free running test and it draws a current quite a bit larger than 75 amperes it is an indication that there is a ground or short circuit in the motor. Troubles of this kind are likely to occur due to grounded brush holders, grounded main motor terminal, grounded armature winding, grounded field windings, short circuited armature coils, and short circuited field coils.

The tests for grounds in the case of the motor are practically the same as in the case of the generator, but the shorts can not be easily located as in the case of the generator, on account of the very low resistance of the armature windings. The only practical method of locating shorts in armature coils is by means of a "growler" unless the trouble is indicated visually by burned or flatted commutator bars.

Maintenance of Storage Battery

The storage battery is really the heart of the electrical system and for this very reason it should not be neglected. The principal points to bear in mind in taking care of the storage battery are the following:

(a) Keep the plates covered with electrolyte by adding water or acid as conditions may require.

(b) The battery should ke kept in a charged condition and under no circumstances allowed to stand for any length of time in a discharged condition.

(c) The terminals to the battery should be cleaned occasionally so as to prevent undue corrosion.

(d) The battery should be firmly anchored in position so as to prevent its being bounced about.

Maintenance of the Electric Wiring

In maintaining the electric wiring in connection with the F. A. starting and lighting system the following suggestions should be observed.

(a) See that all connections are clean, tight and making good electrical contact.

(b) See that all wires are properly anchored in place and not subject to mechanical abrasion.

(c) Keep all wires as free from dirt and oil as possible.

(d) Inspect the ground connections occasionally to see that they are tight and making good electrical contact.

CHAPTER XXXIX

Tables of Electrical Equipment, 1916 to 1920 Cars

TO supplement the wiring diagrams on the preceding pages there is offered in the section following tables of the electrical equipment of passenger cars for the past five years. Both in conjunction with the diagrams and as independent data the tables will be valuable to owners and service men. The men employed in the electrical departments of service stations daily are confronted with electrical problems wherein it is desired to know what type and size fuses are used on certain cars, what the lamp voltage is, whether the system is two-wire or grounded, whether the lamp bulbs are single or double contact, if the dash and taillight are in series, whether the generator has third-brush regulation or inherent regulation, and a host of other similar questions.

To this end the electrical specifications of passenger cars have been prepared in the form of condensed tables to assist service station employees and car owners in immediately ascertaining the nature of the electrical system used on any particular car, together with the details of that system. This eliminates all guess work and speeds up service because the repairman then is in position to pick out exactly the right type of fuse, the right lamp bulbs, etc. Those that must look after the maintenance of electric systems, thus have in a nutshell the information needed in their daily work, which would require considerable effort to get otherwise. Besides it offers the chance for substitution in certain cases, so that if the service station happens to be out of a certain article, a glance at the specifications will show what might be substituted, inasmuch as the article may be obtainable in some other establishment.

Likewise these tables will assist the owner in purchasing equipment such as bulbs, plugs, etc.

Electrical Equipment of 1916 Cars

MAKE and MODEL OF CAR	Make of System	No. of Units	Make of Battery	No. of Cells	Capacity Ampere Hours	Voltage Lamps	Voltage Starter	Headlight C. P.	Wiring System
Abbott	Remy	2	Willard	3	80	..	6	20	S.
Allen	Westinghouse.	2	Gould	2	80	7	6	15	S.
Apperson	Bijur	2	Willard	3	80	6	6	18	D.
Auburn-40	Delco	1	Willard	3	80	6	6	15	S.
Auburn	Remy	2	Willard	3	60	6	6	15	S.
Bell	Disco	1	Willard	6	35	12	12	16	S.
Brewster	U. S. L.	1	U. S. L.	6	...	12	12	40	D.
Briscoe	Apelco	1	Willard	3	70	7	7	15	S.
Buick	Delco	1	Exide	3	80, 100	6	6	16–21	S.
Cadillac	Delco	1	Exide	3	130	8	6	18	S.
Case	Westinghouse.	1	Exide	3	80	7.5	6	18	S.
Chadwick	Westinghouse.	2	Willard	3	100	6	6	20	S.
Chalmers	Entz	1	U. S. L.	9	50	21	18	21	D.
Chalmers 32	Gray & Davis.	2	Willard	3	80	7	6	15	S.
Chandler	Gray & Davis.	2	Willard	3	80	7	6	18	S.
Chevrolet	Auto-Lite	1	Willard	3	80	6	6	18	S.
Cole	Delco	2	Exide	3	80	6	6	18	S.
Crawford	Westinghouse.	1	Gould	3	...	..	..	15	S.
Crow	Disco	1	Detroit	6	35	12	12	15	S.
Cunningham	Westinghouse.	2	Willard	3	120	6	6	15	S.
Daniels	Westinghouse.	1	Willard	3	100	6	6	21	S.
Davis	Delco	1	Willard	3	80	6	6	18	S.
Detroiter F.	Dyneto	1	Detroit	6	35	12	12	14	S.
Detroiter 45	Auto-Lite	2	Willard	3	80	6	6	18	S.
Dodge	North East.	1	Willard	5	42	14	12	15	S.
Dorris	Westinghouse.	2	Willard	3	100	7	6	15	S.
Dort	Westinghouse.	2	Willard	3	80	6	6	16	S.
Empire	Auto-Lite	2	Willard	3	80	7	6	15	S.
Enger	Westinghouse.	2	Gould	3	80	6	6	16	S.
Fiat	Rushmore	2	U. S. L.	3	120	6	6	15	S.
Franklin	Dyneto	1	Willard	6	60	14	12.	21	D.
Glide	Westinghouse.	1	Presto	3	80	6	6	16	S.
Grant	Allis-Chalmers	1	Wright	3	80	6	6	15	S.
Great West.	W. Leonard.	1	Willard	3	80	6	6	15	D.
H. A. L.	Westinghouse.	2	Gould	3	100	6	6	15	S.
Halladay	Westinghouse.	2	Willard	3	100	6–8	6	6	S.
Haynes	Leece-Nev.	1	Willard	3	100	6	6	..	S.
Herff-Brooks	Apelco	1	Willard	3	100	6	6	16	S.
Hollier	Apelco	1	Willard	6	40	12	12	16	D.
Hudson	Delco	1	Exide	3	80	7.2	7.2	15	S.
Hupp.	Bijur	2	Willard	3	60	7–8	6	15	S.
Imperial	Westinghouse.	2	Willard	3	100	6–8	6	21	S.
Interstate	Remy	2	Willard	3	80	6	6	16	S.
Jackson	Auto-Lite	2	Willard	3	100	6	6	15	S.
Jeffery	Bijur	2	U. S. L.	3	80	7.5	6	18	S.
Kearns	Disco	1	Pumpelly	6	60	12	12	10	..
King D	W. Leonard.	2	Willard	3	80	6	6	15	S.
King E	W. Leonard.	1	Willard	3	80	6	6	15	S.
Kissel	West. & Kissel	2	Willard	3	108	7	7	18	S.
Kline	Westinghouse.	2	Willard	3	90	6	6	15	S.
Lenox	Westinghouse.	2	Exide	3	100	6	6	15	S.
Lexington	Westinghouse.	2	Willard	3	100	6	6	16	S.
Locomobile	Westinghouse.	2	Willard	3	120	6–7	5.8	21	S.
Lozier	Gray & Davis.	2	Willard	3	80	6	6	18–21	..
L. P. C.	Remy	1	Willard	6	100	12–14	12	15	S.
McFarlan	Westinghouse.	2	Gould	3	120	7	7	21	S.

Electrical Equipment of 1916 Cars—Concluded

MAKE and MODEL OF CAR	Make of System	No. of Units	Make of Battery	No. of Cells	Capacity Ampere Hours	Voltage Lamps	Voltage Starter	Headlight C. P.	Wiring System
Madison	Remy	2	Willard	3	60	66	..	15	S.
Marion	Westinghouse.	1	Willard	3	120	6	6	55	S.
Marmon	Bosch	2	Willard	6	60	12	12	25	S.
Maxwell	Simms-Huff	1	Presto	6	35	7	6	12	S.
Mecca	Disco	2	Exide	6	80	..	12	15	S.
Mercer	U. S. L.	1	U. S. L.	6	100	12	12	18	S.
Metz	Gray & Davis.	2	Willard	3	60	6	6	15	D.
Mitchell-6	Apelco	1	Willard	6	120	7	12	15	D.
Mitchell	Westinghouse.	2	Willard	3	120	7	7	15	S.
Moline	Wagner gen. Auto-L. starter								
Monroe	Auto-Lite	2	Willard	3	60–66	6	6	18	S.
Moon	Delco	1	Willard	3	80	6	6	15	S.
National	Westinghouse.	2	Willard	3	95	6	6	15	D.
Norwalk	Westinghouse.	2	Willard	3	80	6	12	20	D.
Oakland-32	Remy	2	Willard	3	..	7	7	12	S.
Oakland-38, 50.	Delco	1	Exide	3	80	7	7	12	S.
Olds.	Delco	1	Exide	3	80	6–7	6	18	S.
Overland	Auto-Lite	2	Willard	3	80, 120	6	6	16	S.
Owen	Owen		Willard	2	80	28	24	24	D.
Packard	Bijur	2	Willard	3	120	7	7	24	D.
Paige	Gray & Davis.	2	Willard	3	90	7	6	15	S.
Paterson	Delco	2	Willard	3	80	6	6	16	S.
Pathfinder	Westinghouse.	2	Willard	3	60	6	6	15	S.
Peerless	Gray & Davis.	2	Willard	3	80	6–7	6	15	S.
Pierce-Arrow	Westinghouse.	2	Exide	3	135	6–7	6	21	S.
Pilot	Westinghouse.	2	Willard	3	100	6	6	15	S.
Pilot	Delco	1	Willard	3	100	6	6	15	S.
Premier	Westinghouse.	2	Willard	3	120	6	6	16	S.
Pullman	Apelco	2	G. Lead	6	60	6	12	2	D.
Regal	Dyneto	1	Gould	6	35, 50	12	12	21	S.
Remington	Dyneto	2	Gould	3	...	6	6	..	..
Reo	Remy	2	Willard	3	100	7	6	17	D.
Republic	Delco	1	Exide	3	...	6	6	16	D.
Ross	Robbins & M.	2	U. S. L.	3	80	6	6	15	D.
Saxon	Wagner gen Detroit start.	2	Exide	3	80	6	6	15	S.
Scripps-B	Wagner	2	Willard	3	80	6	6	16	S.
Simplex-Crane	Rushmore	2	Gould	3	120	7	7	40	S.
Singer	Westinghouse.	2	Gould	3	120	6	6	21	S.
S. J. R.	Allis-Chalm.	2	Willard	3	100	6	6	..	S.
Spaulding	Entz	1	Willard	9	50	18	18	15	D.
Standard	Westinghouse.	1	Gould	3	80	6	6	15	S.
States	Allis-Chal.	1	U. S. L.	3	80	6	6	14	S.
Stearns	Westinghouse.	2	Willard	6	80	12	12	18	S.
Sterling	Wagner	2	Gould	3	80	6	6	15	S.
Stewart	Westinghouse.	2	Gould	3	100	6	6	15	S.
Studebaker	Wagner	2	Willard	3	100	7	6	15	S.
Stutz	Remy	1	Willard	3	120	7	7	21	D.
Sun	Remy	2	Willard	3	80	6	6	15	S.
Velie	Gray & Davis.	2	Willard	3	80	6	6	15	S.
Westcott	Delco	1	Willard	3	100	7	6	15	S.
White	White	1	Exide	9	35, 60	21	21	21	D.
Willys-K.	Auto-Lite	2	Willard	3	120	6	6	16	S.
Winton	Bijur	2	Willard	3	120	6	6	15	S.

Complete Electrical Equipment

	STARTING & LIGHTING				BATTERY			HEADLIGHTS		
MAKE and MODEL OF CAR	Make.	Units.	Voltage.	Wiring	Make.	No. of Cells.	Amp. hours.	Type.	C. P. Main.	C. P. Small.
Abbott 6-44	Remy	2	6	Sing	Willard	3	100	2 Bulb	16	4
Allen Classic	West	2	6	Sing	Gould	3	80	2 Bulb	18	4
Alter C	Remy	1	12	Sing	Willard	12	...	1 Bulb	18	..
American Six	G & D	2	6-7	Sing	Willard	3	100	2 Bulb	15	4
Anderson	West	2	6	Sing	Willard	3	90	1 Bulb	18	..
Ap'rson 6-17,8-17	Bijur	2	6	Dbl	Willard	3	80	1 Bulb	18	..
Arbenz	Disco	2	6	Sing	G L B	3	35	2 Bulb	15	6
Auburn 6-39	Remy	2	6	Sing	Willard	3	90	2 Bulb	15	4
Auburn 6-44	Delco	1	6	Sing	Willard	3	100	1 Bulb	16	..
Austin 12	Delco	2	6	Sing	Willard	3	48.8	2 Bulb	24	4
Bour-Davis 17	G & D	2	6	Sing	Detroit	3	100	2 Bulb	18	6
Briscoe 24	Split	2	6	Sing	Detroit	3	80	1 Bulb	15	..
Buick D-4	Delco	1	6	Sing	Exide	3	100	2 Bulb	16	4
Buick D-6	Delco	1	6	Sing	Exide	3	100	2 Bulb	16	4
Cadillac 55	Delco	1	6	Sing	Exide	3	100	1 Bulb	18	..
Case T 17	A-Lite	2	6	Sing	Willard	3	90	2 Bulb	18	4
Chalmers 6-30	West	2	6	Sing	Willard	3	80	2 Bulb	15	4
Chandler 17	G & D	2	6-7	Sing	Willard	3	86	2 Bulb	18	4
Chevrolet 490	A-Lite	2	6	Sing	Willard	3	80	1 Bulb	16	..
Chevrolet F-2	A-Lite	2	6	Sing	Willard	3	80	1 Bulb	16	..
Cole 860	Delco	2	6	Sing	Exide	3	100	1 Bulb	16	..
Columbia D	W. Leonard	2	6	Sing	Willard	3	100	2 Bulb	16	4
Cr. Simplex 5-19	Bosch	2	12	Sing	Gould	6	60	2 Bulb	40	4
Crawford 6-40	West	2	6	Sing	Gould	3	80	2 Bulb	15	4
Crow Elkh't C 35	Dyneto	2	6	Sing	Willard	3	85	2 Bulb	12	4
Cunningham	West	2	6	Sing	Willard	3	100	1 Bulb	15	..
Daniels A	West	2	6	Sing	Willard	3	100	2 Bulb	21	4
Detroiter 6-45	A-Lite	2	6	Sing	Willard	3	85	1 Bulb	18	..
Dixie Flyer	Dyneto	2	6	Dbl	Willard	3	80	1 Bulb	15	..
Dodge	No. East	1	12	Sing	Willard	6	40	1 Bulb	15	..
Dorris 1-B-6	West	2	6	Sing	Exide	3	100	2 Bulb	15	4
Dort 9	West	2	6	Sing	Willard	3	80	1 Bulb	16	..
Drexel	Bijur	2	6	Sing	Willard	3	80	2 Bulb	16	4
Eagle A	Allis-C	1	6	Sing	Willard	3	72	2 Flmnt	15	6
Elgin 17	Wagner	2	6	Sing	Gardiner	3	85	2 Bulb	20	2
Elcar D-E-F	Dyneto	2	6	Sing	Willard	3	90	2 Bulb	15	4
Empire 50	A-Lite	2	6	Sing	PrestoL	3	80	2 Bulb	15	4
Enger	West	2	6	Sing	Gould	3	80	2 Flmnt	15	4
Ford T	....	..	16	Dbl	....	..	....	1 Bulb	..	..
Franklin 9	Dyneto	1	12	Dbl	Willard	..	47½	2 Bulb	21	7
F. R. P. 45	Bosch	2	12	Sing	Willard	3	50	1 Bulb	40	..
Glide 6-40	West	2	6	Sing	Willard	3	80	2 Bulb	16	4
Grant K	Wagner	2	6	Sing	Wilard	3	80	2 Bulb	15	4
Hal 21 A	West	2	6	Sing	Gould	3	80	1 Bulb	15	..
Harroun AA1	....	2	6	Sing	Willard	3	85	2 Flmnt	18	2
Haynes 6	Leece-N	2	6-8	Dbl	Willard	3	120	1 Bulb	16	..
Haynes 12	Leece-N	2	6	Dbl	Willard	3	120	2 Bulb	18	12
Hatfield H	Disco	1	12	Sing	Willard	3	100	2 Bulb	18	4
Hollier 178	Split	1	6-12	Dbl	Willard	6	80	1 Bulb	15	..
Hollier 176	Allis-C	1	6	Sing	Willard	3	80	1 Bulb	15	..
Hud. Super-Six	Delco	1	6	Sing	Exide	3	80	1 Bulb	15	..
Hupmobile	West	2	6	Sing	Willard	3	110	1 Bulb	15	..
Inter-State T	Remy	2	6	Sing	Willard	3	80	1 Bulb	16	..

of 1917 Cars

MAKE and MODEL OF CAR		SIDE LIGHTS			TAIL LIGHTS			DASH LIGHTS			
	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	Fuse Amperage.
Abbott 6-44	S.C.	..	...	....	2	6	S.C.	6	6	....	......
Allen Classic	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	5 & 15
Alter C	S.C.	..	...	....	2	12	S.C.	2	12	S.C.	10 & 15
American Six	S.C.	..	...	....	2	3½	S.C.	2	3½	D.C.	20
Anderson	S.C.	..	...	....	4	6–7	S.C.	4	6–7	....	30
Apperson 6-17, 8-17	D.C.	..	...	....	3	6–8	D.C.	2	6–8	D.C.	10
Arbenz	S.C.	..	...	....	4	6	S.C.	2	6	D.C.	25
Auburn 6-39	S.C.	..	...	....	4	6	S.C.	2	6	D.C.	10
Auburn 6-44	D.C.	4	6	D.C.	4	6	S.C.	2	6	D.C.	......
Austin 12	.....	4	6–8	S.C.	4	6–8	S.C.	4	6–8	S.C.	......
Bour-Davis 17	S.C.	..	...	....	4	6–8	S.C.	2	6–8	D.C.	15
Briscoe 24	S.C.	..	...	....	4	6	S.C.	4	6	D.C.	10
Buick D-4	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Buick D-6	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Cadillac 55	S.C.	6	8	S.C.	2	4	S.C.	2	4	S.C.	......
Case T 17	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	20
Chalmers 6-30	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	15 & 30
Chandler 17	S.C.	..	...	....	2	.....	S.C.	2	.....	S.C.	20
Chevrolet 490	D.C.	..	...	....	2	6–7	S.C.	..	.....	....	10
Chevrolet F-2	D.C.	..	...	....	2	6–7	S.C.	4	6	D.C.	10
Cole 860	S.C.	..	...	....	2	3	S.C.	2	3	D.C.	......
Columbia D	S.C.	..	...	....	4	6	S.C.	..	6	D.C.	......
Cr. Simplex 5-19	S.C.	..	...	....	2	6	D.C.	2	6–12	....	10 & 25
Crawford 6-40	S.C.	..	...	....	4	6	S.C.	2	6	D.C.	5 & 15
Crow Elkhart C 35	S.C.	4	6	S.C.	2	6	S.C.	2	6	S.C.	5
Cunningham	S.C.	4	6	S.C.	2	6	S.C.	4	6	S.C.	15
Daniels A	S.C.	4	6	D.C.	2	6	S.C.	2	6	D.C.	5 & 15
Detroiter 6-45	D.C.	..	...	....	2	6	D.C.	2	6	D.C.	15
Dixie Flyer	D.C.	..	...	....	3	3–3½	D.C.	3	3½	D.C.	10
Dodge	S.C.	..	...	....	2	16	S.C.	2	16	S.C.	......
Dorris 1-B-6	S.C.	2	6	D.C.	2	6	S.C.	2	6–7	S.C.	15
Dort 9	S.C.	..	...	....	4	6–8	S.C.	2	6–8	D.C.	10
Drexel	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	10
Eagle A	S.C.	..	...	....	6	6	S.C.	6	6	S.C.	20
Elgin 17	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	20
Elcar D-E-F	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	15
Empire 50	S.C.	..	...	....	2	3½	S.C.	2	3½	S.C.	20
Enger	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Ford T	D.C.	..	...	....	..	.....	....	..	.....	....	......
Franklin 9	D.C.	..	...	....	4	7	D.C.	4	7	D.C.	10
F. R. P. 45	S.C.	6	12	S.C.	6	12	S.C.	3	12	....	20
Glide 6-40	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	15
Grant K	D.C.	..	...	....	4	7	S.C.	2	7	S.C.	20
Hal 21 A	S.C.	..	...	....	4	6	S.C.	2	6	S.C.	15
Harroun AA1	S.C.	..	...	....	2	7	S.C.	2	7	S.C.	......
Haynes 6	D.C.	..	...	....	2	6–8	D.C.	2	6–8	D.C.	5
Haynes 12	D.C.	..	...	....	2	6–8	D.C.	2	6–8	D.C.	5
Hatfield H	S.C.	..	...	....	4	12	S.C.	2	12	S.C.	......
Hollier 178	S.C.	..	...	....	2	4	S.C.	2	4	D.C.	......
Hollier 176	S.C.	..	...	....	2	4	S.C.	2	4	D.C.	......
Hud. Super-Six	S.C.	..	...	....	2	3–4	S.C.	2	3–4	S.C.	......
Hupmobile	S.C.	..	...	....	2	8	S.C.	2	8	S.C.	10
Inter-State T	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	4 & 15

Complete Electrical Equipment

MAKE and MODEL OF CAR	LIGHTING & STARTING				BATTERY			HEADLIGHTS			
	Make.	Units.	Voltage.	Wiring.	Make.	No. of Cells.	Amp. hours.		Type.	C. P. Main.	C. P. Small.
Jackson 349.....	A-Lite	2	6-8	Sing	Willard	3	80	1	Bulb	15	..
Jeffery 671......	Bijur	2	6	Sing	U S L	3	80	2	Bulb	18	4
Jordan	Bijur	2	6	Sing	Willard	3	80	2	Bulb	18	4
Kent	Bosch	2	12	Dbl	Willard	3	100	2	Bulb	21	4
King E E.......	W. Leonard	2	6	Sing	Willard	3	80	2	Bulb	15	4
Kissel Kar...... 100 Pt. 6	Own starter Remy Gen.	2	6	Sing	Willard	..	86	1	Bulb	18	..
Kissel Kar...... 6-42	Own starter West. Gen.	2	6	Sing	Willard	..	108	2	Bulb	21	6
Kline 38........	West	2	6	Sing	Willard	3	90	2	Bulb	15	4
Lexington 6-0-17.	West	2	6	Sing	Willard	3	80	2	Bulb	21	8
Lexington 6-P.	West	2	6	Sing	Willard	3	100	2	Bulb	16	4
Liberty 10-A....	Delco	2	6-8	Sing	Willard	3	80	2	Bulb	15	4
Locomobile	West	2	6-8	Sing	Willard	3	120	1	Bulb	21	..
Lozier 82.......	G & D	2	6	Sing	Willard	3	80	1	Bulb	6	..
McFarlan Six...	West	2	6	Sing	Willard	3	120	2	Bulb	18	4
Madison 1917....	Remy	2	6-7	Sing	Willard	3	100	2	Bulb	15	6
Maibohm A.....	Disco	1	12	Sing	Detroit	6	60	2	Flmnt	18	2
Majestic M.....	W. Leonard	2	6	Sing	Willard	..	100	2	Bulb	16	4
Mar. H'dl'y 6-40.	West	2	6	Sing	Willard	3	80	2	Bulb	18	4
Mar. H'dl'y 6-60.	West	2	6	Sing	Willard	3	80	2	Bulb	21	4
Marmon 34.....	Bosch	2	12	Sing	Willard	6	50	[illegible]	Bulb	24	8
Maxwell 25.....	Simms H	1	12	Sing	PrestoL	6	35	1	Bulb	15	..
Mercer 22-73....	U S L	1	12	Sing	U S L	6	100	2	Bulb	25	4
Metz	G & D	2	6	Sing	Willard	3	70	2	Bulb	15	4
Mitchell D-40...	Split	2	6	Sing	Willard	3	90	1	Bulb	15	..
Mitchell C-42...	West	2	6	Sing	Willard	3	110	1	Bulb	15	..
Moline Knight G.	A-Lite start Wagner Gen.	2	6	Dbl	Willard	3	...	2	Bulb	15	4
Moline Knight...	A-Lite start Wagner Gen.	2	6	Dbl	Willard	3	...	2	Bulb	15	4
Monroe M-3.....	A-Lite	2	6	Dbl	Willard	3	80	1	Bulb	..	..
Monroe M-4.....	A-Lite	2	6	Dbl	Willard	3	80	2	Bulb	..	..
Moon 6-43......	Delco	2	6	Sing	Willard	3	103	1	Bulb	15	..
Moon 6-66......	Delco	2	6	Sing	Willard	3	103	2	Bulb	15	4
Moore 30.......	Disco	2	6	Sing	Detroit	6	64	1	Bulb	16	..
Murray 70-T....	West	2	6-8	Sing	Willard	3	110	2	Bulb	18	4
National 12.....	Bijur	2	6	Sing	Willard	3	100	2	Bulb	18	4
National 6......	West	2	6	Sing	Willard	3	95	2	Bulb	18	4
Oakland 34.....	Delco	2	6	Sing	Exide	3	80	1	Bulb	12	..
Oakland 50.....	Delco	2	6	Sing	Exide	3	80	1	Bulb	15	..
Ogren 6-50......	West	1	6-8	Dbl	Willard	..	...	2	Bulb	6	2
Oldsmobile 45...	Delco	2	6	Sing	Exide	3	80	2	Bulb	16	6
Overland, all models.....	A-Lite	2	6	Sing	USL, Willard,Gould	3	80	1	Bulb	15	..
Packard 2-25....	Bijur	2	6-8	Dbl	Willard	3	110	2	Bulb	24	6
Paige 6-38......	G & D	2	6-8	Sing	Willard	3	108	2	Bulb	15	4
Partin-P'lm'r 20.	Allis-C	1	6	Sing	Detroit	3	80	2	Bulb	21	2
Partin-P'lm'r 32.	Disco	2	6	Sing	Detroit	3	80	2	Bulb	21	2
Paterson 6-45...	Delco	2	6	Sing	Willard	3	40	2	Bulb	16	4
Pathfinder 3-B..	Delco	2	6	Sing	Willard	..	120	2	Bulb	16	4
Peerless 56-2....	A-Lite	2	6	Sing	Willard	3	125	2	Bulb	18	4

S = Single; D = Double

of 1917 Cars—Continued

		SIDE LIGHTS			TAIL LIGHTS			DASH LIGHTS			
MAKE and MODEL OF CAR	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	Fuse Amperage.
Jackson 349	D.C.	..	...	....	2	6–8	S.C.	2	6–8	D.C.	20
Jeffery 671	S.C.	..	...	....	3	8	S.C.	3	8	S.C.	......
Jordan	S.C.	..	...	....	3	7½	S.C.	3	7½	S.C.	20
Kent	S.C.	..	...	....	4	12	S.C.	4	12	S.C.	......
King E. E	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	10
Kissel Kar 100 Pt. 6.	D.C.	..	...	....	3	6	S.C.	2	6	D.C.	20
Kissel Kar 6-42	D.C.	..	...	....	3	6	D.C.	2	6	D.C.	20
Kline 38	S.C.	..	...	....	6	6	S.C.	4	6	....	5 & 15
Lexington 6-0-17	S.C.	..	...	....	4	6	S.C.	4	6	D.C.	5 & 15
Lexington 6-P	D.C.	..	...	....	4	6	S.C.	4	6	D.C.	4 & 15
Liberty 10-A	S.C.	4	6–8	S.C.	2	6–8	S.C.	2	6–8	S.C.	......
Locomobile	S.C.	6	6–8	S.C.	4	6 8	S.C.	2	6–8	C'bra	10
Lozier 82	D.C.	4	6	S.C.	4	6	S.C.	4	6	S.C.	......
McFarlan Six	S.C.	..	...	....	4	6	S.C.	4	6	D.C.	10
Madison 1917	D.C.	..	...	....	4	6–7	D.C.	6	6–7	D.C.	4
Malbohm A	S.C.	18	12	S.C.	2	12	S.C.	6	12	S.C.	30
Majestic M	S.C.	..	...	....	4	6	S.C.	4	6	....	......
Mar. Handley 6-40	S.C.	..	...	....	2	7	S.C.	2	7	S.C.	30
Mar. Handley 6-60	S.C.	..	...	....	2	7	S.C.	2	7	S.C.	30
Marmon 34	S.C.	4	12	S.C.	4	12	S.C.	2	12	S.C.	20
Maxwell 25	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	20
Mercer 22-73	S.C.	..	...	....	4	12–16	S.C.	4	12–16	S.C.	6 & 30
Metz	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	20
Mitchell D-40	D.C.	..	...	....	2	6–8	D.C.	2	6–8	D.C.	20
Mitchell C-42	D.C.	..	...	....	2	6–8	D.C.	2	6–8	D.C.	20
Moline Knight G	S.C.	..	...	....	2	6	S.C.	4	6	S.C.	20
Moline Knight	S.C.	..	...	....	2	6	S.C.	4	6	S.C.	20
Monroe M-3		..	...	....	16	6	D.C.	..	.....	....	......
Monroe M-4		..	...	....	16	6	D.C.	16	6	D.C.	......
Moon 6-43	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	......
Moon 6-66	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	......
Moore 30	S.C.	..	...	....	6	6	S.C.	..	.....	....	......
Murray 70-T	S.C.	..	...	....	2	6–8	S.C.	2	6–8	S.C,	5 & 15
National 12	S.C.	..	...	....	3	7	S.C.	2	7	D.C.	......
National 6	S.C.	..	...	....	3	7	S.C.	2	7	D.C.	......
Oakland 34	S.C.	..	...	....	2	7	S.C.	2	12	D.C.	......
Oakland 50	S.C.	..	...	....	2	7	S.C.	2	7	S.C.	......
Ogren 6-50	D.C.	..	...	....	2	6	D.C.	2	.....	D.C.	......
Oldsmobile 45	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Overland, all models	D.C.	4	6	D.C.	2	3	S.C.	2	3	S.C.	10
Packard 2-25	D.C.	4	6–8	D.C.	2	6–8	D.C.	4	6–8	D.C.	10
Paige 6-38	S.C.	..	...	....	2	6–8	S.C.	2	6–8	D.C.	20
Partin-Palmer 20	S.C.	..	...	....	4	6	S.C.	..	.....	....	......
Partin-Palmer 32	S.C.	..	...	....	4	6–8	S.C.	2	6–8	D.C.	......
Paterson 6-45	S.C.	..	...	....	4	3½	S.C.	4	3—	C'bra	.....
Pathfinder 3-B	S.C.	..	...	....	4	6	S.C.	4	6	S.C.	......
Peerless 56-2	S.C.	..	...	....	2	7	S.C.	2	7	S.C.	20

Complete Electrical Equipment

MAKE and MODEL OF CAR	STARTING & LIGHTING				BATTERY			HEADLIGHTS		
	Make	Units	Voltage	Wiring	Make	No. of Cells	Amp. Hours		Type	C. P. Main	C. P. Small
Pennsy R........	Dyneto	2	6	Sing	Willard	3	85	1	Bulb	15	..
Pierce-Arrow 38.	West	2	6	Sing	Exide	3	125	1	Bulb	21	..
Pierce-Arrow 48.	West	2	6	Sing	Exide	3	125	1	Bulb	21	..
Pierce-Arrow 66.	West	2	6	Sing	Exide	3	125	1	Bulb	21	..
Pilliod F........	A-Lite	2	6	Sing	U S L	..	100	2	Bulb	15	6
Pilot 6-45........	Delco	2	6	Sing	Exide	3	80	1	Bulb	15	..
Premier 6-B.....	Delco	1	6-7	Sing	Willard	3	108	2	Bulb	21	4
Princess F......	Disco	2	6	Sing	Detroit	6	80	1	Bulb	12	..
Pullman 424....	Apelco	2	6	Sing	Prestol.	3	80	2	Bulb	15	4
Regal J.........	Heinze-S	2	6	Sing	U S L	3	80	1	Bulb	21	..
Reo R & S.......	Remy	2	6	Dbl	Willard	3	108	1	Bulb	15	..
Reo M & N......	Remy	2	6	Dbl	Willard	3	108	1	Bulb	15	..
Roamer RA.....	Bijur	2	6	Sing	Willard	3	80	2	Bulb	15	4
Ross 8C.........	W. Leonard	2	6	Sing	U S L	3	80	2	Bulb	15	4
Saxon S 4......	Wagner	2	6	Sing	Exide	3	80	1	Bulb	15	..
Saxon B 5 R....	Wagner	2	6	Sing	Exide	3	80	1	Bulb	15	..
Scripps Booth D.	Wagner	2	6	Sing	Willard	3	86	2	Bulb	16	4
Singer 17........	West	1	6	Sing	Willard	3	120	2	Flm't	32	6
Standard F.....	Apelco	2	6	Sing	Willard	3	80	2	Bulb	18	4
Standard E.....	West	2	6	Sing	Gould	3	80	2	Bulb	18	4
States B.........	Dyneto	2	6	Sing	U S L	..	80	2	Bulb	21	3
Stearns SK 8....	West	2	12	Sing	Willard	6	100	2	Bulb	24	4
Stearns SKL 4..	West	2	12	Sing	Willard	6	80	2	Bulb	18	4
Stephens Six....	A-Lite	2	6	Sing	Willard	3	80	1	Bulb	15	..
Studebaker SF...	Wagner	3	6-8	Sing	Willard	3	100	1	Bulb	12	..
Sun 17..........	Remy	2	6	Sing	Willard	3	...	1	Bulb	18	..
Velie 27.........	Remy	2	6	Sing	Willard	3	90	2	Bulb	15	4
Velie 28.........	Remy	2	6	Sing	Willard	3	85	2	Bulb	15	4
Westcott 17.....	Delco	2	6	Sing	Willard	3	120	2	Bulb	15	4
Willys-Knight ..	A-Lite	2	6	Sing	U S L or	3	80	1	Bulb	15	..
White 16-V-4....	Leece-N	2	12	Dbl	Willard	6	70	2	Bulb	21	4
Winton 22.......	Bijur	2	6	Sing	Willard	3	120	2	Bulb	21	12
Winton 22-A....	Bijur	2	6	Sing	Willard	3	100	2	Bulb	21	12
Yale 8..........	Disco	2	6	Sing	Willard	3	130	1	Bulb	15	..

Complete Electrical Equipment

MAKE and MODEL OF CAR	STARTING AND LIGHTING				IGNITION			HEAD LIGHT
	Make	Voltage	Units	Wiring	Make	Source of Current	Spark Plug	Base
Abbott 6-44.........	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Abbott 6-60.........	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Allen 41...........	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Sing.
American Six......	G & D	6	2	Sing.	G & D	Batt.	⅞	....
Anderson 20.......	West	6	1	Sing.	Conn	Batt.	⅞	....
Apperson 6-18......	Bijur	6	2	Dbl.	Remy	Batt.	⅞	....
Apperson 8-18......	Bijur	6	2	Dbl.	Remy	Batt.	⅞	Dbl.
Auburn 6-39.......	Remy	6	2	Sing	Remy	Batt.	⅞	....
Auburn 6-44.......	Delco	6	1	Sing.	Delco	Batt.	⅞	....

of 1917 Cars—Concluded

		SIDE LIGHTS			TAIL LIGHTS			DASH LIGHTS			
MAKE and MODEL OF CAR	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	C. P.	Voltage.	Base.	Fuse Amperage.
Pennsy R.	S.C.	..	...	....	2	3	D.C.	2	3	D.C.	......
Pierce-Arrow 38	S.C.	4	6	S.C.	2	6	S.C.	2	6	S.C.	5,10&30
Pierce-Arrow 48	S.C.	4	6	S.C.	2	6	S.C.	2	6	S.C.	5,10&30
Pierce-Arrow 66	S.C.	4	6	S.C.	2	6	S.C.	2	6	S.C.	5,10&30
Pilliod F	S.C.	..	...	....	6	6	S.C.	6	6	D.C.	15
Pilot 6-45	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	......
Premier 6-B	S.C.	..	...	....	2	6–7	S.C.	2	6–7	C'bra	.....
Princess F	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Pullman 424	S.C.	..	...	....	2	6–7	S.C.	2	6–7	S.C.	15
Regal J	S.C.	..	...	....	4	7	S.C.	2	7	S.C.	......
Reo R & S	D.C.	..	...	....	3	3–4	D.C.	3	3–4	D.C.	5
Reo M & N	D.C.	..	...	....	3	3–4	D.C.	3	3–4	D.C.	5
Roamer RA	S C.	..	...	....	2	6	S.C.	2	6	S.C.	10
Ross 8 C	D.C.	..	...	....	4	6	D.C.	2	6	D.C.	20
Saxon S 4	S.C.	..	...	....	2	6	S.C.	2	6	D.C.	15
Saxon B 5 R	S.C.	..	...	....	2	6	S.C.	..	....	....	15
Scripps Booth D.	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	......
Singer 17	S.C.	6	6	S.C.	2	6	S.C.	2	6	D.C.	5 & 15
Standard F	S.C.	..	...	....	2	3½	S.C.	2	3½	S.C.	5 & 15
Standard E	S.C.	..	...	....	2	3½	S.C.	3	3½	S.C.	5 & 15
States B	....	..	...	....	3	6	S.C.	3	6	S.C.	......
Stearns SK 8	S.C.	..	...	....	2	12	S.C.	2	12	S.C.	20
Stearns SKL 4	S.C.	..	...	....	2	12	S.C.	2	12	S.C.	20
Stephens Six	D.C.	..	...	....	2	3	S.C.	2	3	D.C.	......
Studebaker SF	S.C.	..	...	....	2	6–8	S.C.	2	6–8	S.C.	10
Sun 17	S.C.	..	...	....	2	6	S.C.	2	6	S.C.	20
Velie 27	S.C.	..	...	....	2	3	S.C.	2	3	S.C.	5
Velie 28	S.C.	..	...	....	2	3	S.C.	2	3	D.C.	5
Wescott 17	S.C.	..	...	....	2	3½	S.C.	2	3½	D.C.	25
Willys-Knight	D.C.	..	...	....	2	3	S.C.	2	3	S.C.	10
White 16-V-4	D.C.	..	...	....	2	12	D.C.	2	12	D.C.	......
Winton 22	S.C.	..	...	....	4	6–7	S.C.	2	6–8	S.C.	20
Winton 22-A	S.C.	..	...	....	4	6–7	S.C.	2	6–8	S.C.	20
Yale 8	S.C.	..	...	....	2	3	S.C.	2	3	S.C.	......

of 1918 Cars

	HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
MAKE and MODEL OF CAR	Volts	CP.	Volts	CP.	Volts	CP.	Volts	CP.
Abbott 6-44	...	..	...	..	...	..	...	..
Abbott 6-60	...	..	...	..	...	..	...	..
Allen 41	6–8	18	‡6–8	..	6–8	2	6–8	2
American Six	...	..	...	..	...	..	...	..
Anderson 20	...	..	...	..	...	..	...	..
Apperson 6-18	...	..	...	..	...	..	...	..
Apperson 8-18	6–8	18	...	..	‡6–8	2	‡6–8	2
Auburn 6-39	...	..	...	..	...	..	...	..
Auburn 6-44	...	..	...	..	...	..	...	..

Complete Electrical Equipment

	STARTING AND LIGHTING				IGNITION			HEAD LIGHT
MAKE and MODEL OF CAR	Make	Voltage	Units	Wiring	Make	Source of Current	Spark Plug	Base
Austin 12	Delco	6	2	Sing	Delco	Batt.	⅞	Sing.
Biddle	G & D	6	2	Sing.	Eisemann	Mag.	⅞	Sing.
Bour Davis 18-A	Bijur	6	2	Sing.	Eisemann	Mag.	⅞	....
Bour Davis 18-B	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Brewster	U. S. L.	6	..	....	....	Mag.	⅞	....
Briscoe	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Sing.
Buick E-4	Delco	6	1	Sing.	Delco	Batt.	⅞	Sing.
Buick E-6	Delco	6	1	Sing.	Delco	Batt.	⅞	Sing.
Bush 18	Dyneto	6	2	Sing.	Delco	Batt.	⅞	....
Cadillac 57	Delco	6	1	Sing.	Delco	Batt.	⅞	Sing.
Campbell Four	Auto-L	6	2	Sing.	A Kent	Batt.	⅞	....
Case U	West	6	2	Sing.	West	Batt.	⅞	Sing.
Chalmers 6-30	West	6	2	Sing	Remy	Batt.	⅞	Sing.
Chandler 17	West	6	2	Sing	Bosch	Mag.	⅞	Sing.
Chevrolet 490	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Dbl
Chevrolet F	Auto-L	6	2	Sing.	Remy	Batt.	⅞	Dbl.
Chevrolet D	Auto-L	6	2	Sing.	Remy	Batt.	⅞	Dbl.
Cole 860	Delco	6	2	Sing.	Delco	Batt	⅞	Sing.
Columbia Six	R & M	8	2	Sing.	A. Kent	Batt.	⅞	Sing.
Crawford 18-6-40	West	6	1	Sing.	West	Batt.	⅞	....
Crow-Elkhart	Dyneto	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Cunningham V	West	6	2	Sing.	Delco	Batt.	⅞	....
Commonwealth	Dyneto	6	2	Sing.	A. Kent	Batt.	⅞	....
Daniels B	West	6	2	Sing.	West	Batt.	⅞	....
Davis H	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Davis J	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Dispatch	U. S L.	12	1	Dbl.	Delco	Batt.	⅞	....
Dixie Flyer	Dyneto	6	2	Dbl.	Conn	Batt.	⅞	Dbl.
Dodge	N. E.	12	1	Sing.	Delco	Batt.	⅞	Sing.
Dorris 1-C-6	West	6	2	Sing.	Bosch	Mag.	⅞	Sing.
Dort 9	West	6	2	Sing.	Conn	Batt.	⅞	Sing.
Eagle	Wagner	6	2	Sing.	A. Kent	Batt.	⅞	....
Economy 4-36	Dyneto	6	2	Sing.	Conn	Batt.	⅞	....
Economy 8-48	Dyneto	6	2	Sing.	Conn	Batt.	⅞	....
Elcar D-4	Dyneto	6	2	Sing.	A. Kent	Batt.	⅞	Sing.
Elcar D-6	Dyneto	6	2	Sing.	A. Kent	Batt.	⅞	Sing.
Elgin	Wagner	6	2	Sing	Remy	Batt.	⅞	Dbl.
Empire 50	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Empire 70	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Erie 33	Dyneto	6	2	Dbl.	Eisemann	Mag.	⅞	....
Fiat 55	Leece-N	12	2	Sing.	Berling	Mag.	⅞	....
Ford T	Own lighting only			Sing.	Own	Mag.	½	Dbl.
F. R. P	Bosch	12	2	Sing.	Bosch	Mag.	Met.	....
Franklin 9	Dyneto	12	1	Dbl.	A. Kent	Batt.	⅞	Dbl.
Ghent 6-60	Auto-L	6	2	Sing.	Conn	Batt.	⅞	....
Glide 6-40	West	6	2	Sing.	West	Batt.	⅞	....
Grant G	Wagner	6	2	Sing.	Remy	Batt.	⅞	Sing.
Hal 12	West	6	2	Sing.	Remy	Batt.	⅞	....
Harroun AA-1	Remy	6	2	Sing.	A. Kent	Batt.	⅞	Sing.
Harvard 4-25	Wagner	6	2	Sing.	A. Kent	Batt.	⅞	....
Hatfield A	Dyneto	6	2	Sing.	Conn	Batt.	⅞	....
Haynes 6	Leece-N	6	2	Dbl.	Remy	Batt.	⅞	Dbl.
Haynes 12	Leece-N	6	2	Dbl.	Remy	Batt.	⅞	Dbl.
Hollier 196	Split	6	1	Sing.	Remy	Batt.	⅞	....
Hollier 188	Split	6	1	Sing.	A. Kent	Batt.	⅞	....
Homer-Laughlin 188	Disco	12	1	Sing.	A. Kent	Batt.	⅞	....

of 1918 Cars—Continued

MAKE and MODEL OF CAR	HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
	Volts	CP.	Volts	CP.	Volts	CP.	Volts	CP.
Austin 12	6–8	24	6–8	12	6–8	6	6–8	3
Biddle	6–8	24	6–8	4	6–8	2	*6–8	2
Bour-Davis 18-A	...	..	...	..	...	..	...	..
Bour-Davis 18-B	...	..	...	..	...	..	...	..
Brewster	...	..	...	..	...	..	...	..
Briscoe	6–8	21	...	..	6–8	2	6–8	2
Buick E-4	6–8	15	...	..	6–8	2	6–8	2
Buick E-6	6–8	15	...	..	6–8	2	6–8	2
Bush 18	...	..	...	..	...	..	...	..
Cadillac 57	6–8	18	6–8	6	3–4	2	3–4	2
Campbell Four	...	..	...	..	...	..	...	..
Case U	6–8	18	6–8	4	6–8	2	6–8	2
Chalmers 6-30	6–8	15	6–8	4	6–8	2	6–8	2
Chandler 17	6–8	16	6–8	4	6–8	2	6–8	2
Chevrolet 490	6–8	12	†6–8	2	†6–8	2	*6–8	2
Chevrolet F	...	..	...	..	...	..	...	..
Chevrolet D	...	..	...	..	...	..	...	..
Cole 860	6–8	21	...	..	6–8	4	6–8	4
Columbia Six	6–8	15	6–8	4	6–8	2	6–8	2
Crawford 18-6-40	...	..	...	..	...	..	...	..
Crow-Elkhart	6–8	20	...	..	6–8	2	6	2
Cunningham V	...	..	...	..	...	..	...	..
Commonwealth	...	..	...	..	...	..	...	..
Daniels B	...	..	...	..	...	..	...	..
Davis H	6–8	18	...	..	6–8	2	6–8	2
Davis J	6–8	18	...	..	6–8	2	6–8	2
Dispatch	...	..	...	..	...	..	...	..
Dixie Flyer	6–8	15	...	..	3–4	2	3–4	2
Dodge	12–16	16	...	..	12–16	2	12–16	2
Dorris 1-C-6	6–8	15	6–8	4	6–8	2	6–8	2
Dort 9	6–8	16	...	..	6–8	2	6–8	2
Eagle	...	..	...	..	...	..	...	..
Economy 4-36	...	..	...	..	...	..	...	..
Economy 8-48	...	..	...	..	...	..	...	..
Elcar D-4	6–8	21	‡6–8	4	6–8	2	6–8	2
Elcar D-6	6–8	21	‡6–8	4	6–8	2	6–8	2
Elgin	6–8	21	‡6–8	4	†6–8	2	6–8	2
Empire 50	6–8	18–21	...	..	3–4	2	3–4	2
Empire 70	6–8	18–21	...	..	3–4	2	3–4	2
Erie 33	...	..	...	..	...	..	...	..
Fiat 55	...	..	...	..	...	..	...	..
Ford T	6–8	15	Oil	..	Oil	..	...	..
F. R. P	...	..	...	..	...	..	...	..
Franklin 9	12–16	21	12–16	4	6–8	2	12–16	2
Ghent 6-60	...	..	...	..	...	..	...	..
Glide 6-40	...	..	...	..	...	..	...	..
Grant G	6–8	15	‡6–8	4	6–8	2	6–8	2
Hal 12	...	..	...	..	...	..	...	..
Harroun AA-1	6–8	15	...	..	3–4	2	*3–4	2
Harvard 4-25	...	..	...	..	...	..	...	..
Hatfield A	...	..	...	..	...	..	...	..
Haynes 6	6–8	16	...	..	6–8	2	6–8	2
Haynes 12	6–8	16	...	..	6–8	2	6–8	2
Hollier 196	...	..	...	..	...	..	...	..
Hollier 188	...	..	...	..	...	..	...	..
Homer-Laughlin	...	..	...	..	...	..	...	..

Complete Electrical Equipment

MAKE and MODEL OF CAR	STARTING AND LIGHTING				IGNITION			HEAD LIGHT
	Make	Voltage	Units	Wiring	Make	Source of Current	Spark Plug	Base
Hudson Super-Six	Delco	6	1	Sing.	Delco	Batt.	⅞	Sing.
Hupmobile 1 R	Bijur	6	2	Sing.	A. Kent	Batt.	⅞	Sing.
Inter-State T	Remy	6	2	Sing.	Remy	Batt.	⅞	Sing.
Jackson 350	Auto-L	6	2	Sing.	Auto-L	Batt.	⅞	Sing.
Jones 356	Auto-L	6	2	Sing.	Remy	Batt.	⅞	Sing.
Jordan 60	Bijur	6	2	Sing.	Bosch	Mag.	⅞	Sing.
King EE	Bijur	6	2	Sing.	A. Kent	Batt.	⅞	Sing.
Kissel 100 pt	Own	6	2	Sing.	Remy	Batt.	⅞	Sing.
Kissel Dbl-6	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Kline 6-38	West	6	2	Sing.	West	Batt.	⅞	....
Lexington R	West	6	1	Sing.	Conn	Batt.	⅞	Sing.
Liberty 10-B	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Locomobile 38	West	6	2	Sing.	Berling	Mag.	⅞	Sing.
Locomobile 48	West	6	2	Sing.	Berling	Mag.	⅞	Sing.
Madison	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Maibohm A	Disco	6	1	Sing.	A. Kent	Batt.	⅞	Sing.
Maibohm B	Wagner	12	2	Sing.	A. Kent	Batt.	⅞	....
Marion-H'd'ly 6-40	West	6	2	Sing.	West	Batt.	⅞	....
Marion-H'd'ly 6-60	West	6	2	Sing.	West	Batt.	⅞	....
Marmon 34	Bosch	12	2	Sing.	Bosch	Mag.	⅞	Dbl.
Maxwell 25	Simms	12	1	Sing.	A. Kent	Batt.	⅞	Sing.
McFarlan 6	West	6	2	Sing.	West	Batt.	⅞	....
Mercer 22-73	U. S. L.	12	1	Sing.	Bosch	Mag.	⅞	....
Metz 25	West	6	2	Sing.	A. Kent	Batt.	⅞	....
Mitchell D-40	Split	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Mitchell C-42	West	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Moline-Knight C	Auto-L	6	2	Dbl	Conn	Batt.	⅞	Sing.
Moline-Knight G	Auto-L	6	2	Dbl.	Conn	Batt.	⅞	Sing.
Monitor C	Heinze	6	2	Sing.	Heinze	Mag.	⅞	....
Monitor R	Heinze	6	2	Sing.	Heinze	Mag.	⅞	....
Monroe M-6	Auto-L	6	2	Sing.	Conn	Batt.	⅞	....
Moon 6-36	Wagner	6	2	Sing.	Delco	Batt.	⅞	....
Moon 6-45	Delco	6	2	Sing.	Delco	Batt.	⅞	....
Moon 6-66	Delco	6	2	Sing.	Delco	Batt.	⅞	....
Moore	Disco	6	2	Sing.	Dixie	Mag.	⅞	Sing.
Murray 70	West	6	2	Sing.	Dixie	Mag.	⅞	....
Nash 681	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Nash 684	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
National 6	West	6	2	Sing.	Dixie	Mag.	⅞	Sing.
National 12	Bijur	6	2	Sing.	Delco	Batt.	⅞	Sing.
Nelson	U. S. L.	12	1	Sing.	Bosch	Mag.	Met.	Sing.
Norwalk 18	Dyneto	6	2	Sing.	Delco	Batt.	⅞	....
Oakland 34-B	Remy	7	2	Sing.	Remy	Batt.	⅞	Sing.
Oldsmobile 37	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Oldsmobile 45	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Olympian	Auto-L	6	1	Sing.	Conn	Batt.	⅞	....
Overland 90	Auto-L	6	2	Sing.	Conn	Batt.	½	Dbl.
Overland 85-4	Auto-L	6	2	Sing.	Conn	Batt.	½	....
Overland 85-6	Auto-L	6	2	Sing.	Conn	Batt.	⅞	....
Owen-Mag M-25	Own	..	..	....	Bosch	Mag.	⅞	....
Owen-Mag O-36	Own	..	..	....	Bosch	Mag.	⅞	....
Packard 3-25	Bijur	6	2	Sing.	Delco	Batt.	⅞	Sing.
Packard 3-35	Bijur	6	2	Sing.	Delco	Batt.	⅞	Sing.
Paige 6-39	G & D	6	2	Sing.	Remy	Batt.	⅞	Sing.
Paige 6-55	Remy	6	2	Sing.	Remy	Batt.	⅞	Sing.
Pan-American G 6-5	G & D	6	2	Sing.	A. Kent	Batt.	⅞	....

of 1918 Cars—Continued

MAKE and MODEL OF CAR	HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
	Volts	CP.	Volts	CP.	Volts	CP.	Volts	CP.
Hudson Super-Six	6–8	15	6–8	4	3–4	2	3–4	2
Hupmobile 1 R	6–8	15	...	..	6–8	2	6–8	2
Inter-State T	6–8	16	...	..	6–8	2	6–8	2
Jackson 350	6–8	15	...	..	†6–8	2	*6–8	2
Jones 356	6–8	15	6–8	4	*6–8	2	*6–8	2
Jordan 60	6–8	18	6–8	4	6–8	2	6–8	2
King EE	6–8	18	‡6–8	4	6–8	2	6–8	2
Kissel 100 pt	6–8	18–4	...	..	6–8	2	6–8	2
Kissel Dbl-6	6–8	18–12	...	..	6–8	2	6–8	2
Kline 6-38	...	..	...	..	...	..	...	..
Lexington R	6–8	30	6–8	8	6–8	4	6–8	*4
Liberty 10-B	6–8	15	6–8	4	6–8	2	6–8	2
Locomobile 38	6–8	21	6–8	6	6–8	4	6–8	4
Locomobile 48	6–8	21	6–8	6	6–8	4	6–8	4
Madison	12–16	18	12–16	2	6–8	2	6–8	2
Maibohm A	6–8	18	6–8	2	3–4	2	3–4	2
Maibohm B	...	..	...	..	...	..	...	..
Marion-Handley 6-40	...	..	...	..	...	..	...	..
Marion-Handley 6-60	...	..	...	..	...	..	...	..
Marmon 34	6–8	32	...	..	6–8	4	6–8	4
Maxwell 25	6–8	..	...	..	3–4	..	3–4	..
McFarlan 6	6–8	21	...	..	6–8	2	6–8	2
Mercer 22-73	...	..	...	..	...	..	...	..
Metz 25	6–8	24	6–8	4	6–8	4	6–8	4
Mitchell D-40	6–8	15	...	..	6–8	2	6–8	2
Mitchell C-42	6–8	15	...	..	...	..	...	..
Moline-Knight C	6–8	16	6–8	4	6–8	2	6–8	2
Moline-Knight G	6–8	16	6–8	4	6–8	2	6–8	2
Monitor C	...	..	...	..	...	..	...	..
Monitor R	...	..	...	..	...	..	...	..
Monroe M-6	...	..	...	..	...	..	...	..
Moon 6-36	...	..	...	..	...	..	...	..
Moon 6-45	...	..	...	..	...	..	...	..
Moon 6-66	...	..	...	..	...	..	...	..
Moore	6–8	15	...	..	6–8	2	6–8	2
Murray 70	...	..	...	..	...	..	...	..
Nash 681	6–8	18	‡6–8	4	6–8	2	6–8	2
Nash 684	6–8	18	‡6–8	4	6–8	2	6–8	2
National 6	...	..	...	..	...	..	...	..
National 12	...	..	...	..	...	..	...	..
Nelson	...	..	...	..	...	..	...	..
Norwalk 18	...	..	...	..	...	..	...	..
Oakland 34-B	6–8	16	...	..	6–8	2	6–8	2
Oldsmobile 37	6–8	15	6–8	4	6–8	2	6–8	2
Oldsmobile 45	6–8	15	6–8	4	6–8	2	6–8	2
Olympian	...	..	...	..	...	..	...	..
Overland 90	6–8	12	...	..	†3–4	2	†3–4	2
Overland 85-4	...	..	...	..	...	..	...	..
Overland 85-6	...	..	...	..	...	..	...	..
Owen-Mag. M-25	...	..	...	..	...	..	...	..
Owen-Mag. O-36	...	..	...	..	...	..	...	..
Packard 3-25	6–8	24	6–8	4	6–8	2	6–8	2
Packard 3-35	6–8	24	6–8	4	6–8	2	6–8	2
Paige 6-39	6–8	18	6–8	4	6–8	2	6–8	2
Paige 6-55	6–8	18	6–8	4	6–8	2	6–8	2
Pan-American G 6-5	...	..	...	..	...	..	...	..

Complete Electrical Equipment

MAKE and MODEL OF CAR	STARTING AND LIGHTING				IGNITION			HEAD LIGHT
	Make	Voltage	Units	Wiring	Make	Source of Current	Spark Plug	Base
Paterson 6-45	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Pathfinder B	Delco	6	2	Sing.	Delco	Batt.	⅞	....
Peerless 56	Auto-L	6	2	Sing	A Kent	Batt.	⅞	....
Pennsy 4-B	Dyneto	6	2	Sing.	Conn	Batt.	⅞	....
Pennsy 6-S	Heinze	6	2	Sing	Heinze	Batt.	⅞	....
Phianna M	Ward-L	6	2	Dbl.	Bosch	Mag.	Met.	....
Pierce-Arrow 38	West	6	2	Sing.	Bosch	Mag.	⅞	Sing.
Pierce-Arrow 48	West	6	1	Sing.	Bosch	Mag.	⅞	Sing.
Pierce-Arrow 66	West	6	2	Sing.	Bosch	Mag.	⅞	Sing.
Pilot 6-45	Delco	6	2	Sing.	Delco	Batt	⅞	....
Premier 6-C	Delco	6	2	Sing.	Delco	Batt.	⅞	Sing.
Regal 4	Auto-L	6	2	Sing.	A. Kent	Batt.	½	....
Revere	Bijur	6	2	Sing.	Bosch	Mag.	⅞	Dbl.
Reo R	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Reo M	Remy	6	2	Sing.	Remy	Batt.	⅞	....
Ross	Ward-L	6	2	Sing.	A Kent	Batt.	⅞	....
Saxon B-5	Wagner	6	2	Sing.	A. Kent	Batt.	⅞	Sing
Saxon S-4	Wagner	6	2	Sing.	Remy	Batt	⅞	Sing.
Scripps-Booth D	Wagner	6	2	Sing.	Remy	Batt.	⅞	Sing.
Scripps-Booth 8	Wagner	6	2	Sing.	Remy	Batt.	⅞	Sing
Seneca A	Allis-C	6	2	Sing.	Remy	Batt.	⅞	....
Shad-Wyck A	West	6	2	Sing.	Remy	Batt.	⅞	Sing.
Singer 18	West	6	2	Sing.	Eisemann	Mag	⅞	....
Standard G	West	6	2	Sing.	Bosch	Mag	⅞	....
States C-18	Dyneto	6	2	Sing.	Dixie	Mag.	⅞	Sing.
Stearns-Knight 4	West	12	2	Sing.	....	Batt.	⅞	....
Stearns-Knight 8	West	12	2	Sing.	Remy	Batt.	⅞	Sing.
Stephens 70	Delco	6	2	Sing.	Remy	Batt.	⅞	Sing.
Studebaker 4-40	Wagner	6	2	Sing	Delco	Batt.	⅞	Sing.
Studebaker 6-50	Wagner	6	2	Sing	Remy	Batt.	½	Sing.
Stutz	Remy	6	2	Dbl.	Remy	Batt.	½	....
Velie 38	Remy	6	1	Sing.	Bosch	Mag	⅞	Dbl.
Velie 39	Remy	6	1	Sing.	Remy	Batt.	⅞	Sing.
Westcott 18	Delco	6	2	Sing	Remy	Batt.	⅞	Sing.
White	Leece-N	12	2	Dbl.	Delco	Batt.	⅞	Sing.
Willys Six 89	Auto-L	6	2	Dbl	....	Mag.	⅞	Dbl.
Willys-Knight	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Willys-Knight	Auto-L	6	2	Sing.	Conn	Batt.	⅞	Dbl.
Winton 33	Bijur	6	2	Sing.	Conn	Batt	⅞	Sing.
Winton 48	Bijur	6	2	Sing.	Bosch	Mag.	⅞	Sing.
Woods Dual 54	Special	..	..	....	Bosch	Mag.	⅞	Sing.
Yale M	Bijur	6	2	Sing.	A. Kent	Batt.	⅞	....

Abbreviations: *Double contact; †single contact; ‡dimmer. Starting Neville; N. E., North East; R & M, Robbins & Mayers; Ward-L, Ward-tion: Conn, Connecticut; A. Kent, Atwater-Kent; Batt, Battery; Mag,

of 1918 Cars—Concluded

MAKE and MODEL OF CAR	HEAD-LIGHTS Volts	HEAD-LIGHTS CP.	SIDE-LIGHTS Volts	SIDE-LIGHTS CP.	TAIL-LIGHTS Volts	TAIL-LIGHTS CP.	DASH-LIGHTS Volts	DASH-LIGHTS CP.
Paterson 6-45	6–8	12	6–8	4	6–8	4	6–8	4
Pathfinder B	...	..	...	..	...	..	...	..
Peerless 56	...	..	...	..	...	..	...	..
Pennsy 4-B	...	..	...	..	...	..	...	..
Pennsy 6-S	...	..	...	..	...	..	...	..
Phianna M	...	..	...	..	...	..	...	..
Pierce-Arrow 38	6–8	21	6–8	4	6–8	4	6–8	4
Pierce-Arrow 48	6–8	21	6–8	4	6–8	4	6–8	4
Pierce-Arrow 66	6–8	21	6–8	4	6–8	4	6–8	4
Pilot 6-45	...	..	...	..	...	..	...	..
Premier 6-C	6–8	21	6–8	4	6–8	2	6–8	2
Regal 4	...	..	...	..	...	..	...	..
Revere	6–8	20	6–8	10	6–8	8	6–8	10
Reo R	...	..	...	..	...	..	...	..
Reo M	...	..	...	..	...	..	...	..
Ross	...	..	...	..	...	..	...	..
Saxon B-5	6–8	18	...	..	6–8	2–4	6–8	2–4
Saxon S-4	6–8	18	...	..	6–8	2–4	6–8	2–4
Scripps-Booth D	...	..	...	..	...	..	...	..
Scripps-Booth 8	...	..	...	..	...	..	...	..
Seneca A	...	..	...	..	...	..	...	..
Shad-Wyck A	...	..	...	..	...	..	...	..
Singer 18	...	..	...	..	...	..	...	..
Standard G	6–8	18	6–8	4	6–8	2	*6–8	2
States C-18	...	..	...	..	...	..	...	..
Stearns-Knight 4	12–16	18	12–16	4	12–16	2	12	2
Stearns-Knight 8	12–16	18	12–16	4	12–16	2	12	2
Stephens 70	6–8	15	*6–8	4	6–8	2	*6–8	2
Studebaker 4-40	6–8	12	...	..	6–8	2	6–8	2
Studebaker 6-50	...	..	...	..	...	..	...	..
Stutz	6–8	18	6–8	21	6–8	2	6–8	2
Velie 38	6–8	15	...	4	3–4	2	3–4	2
Velie 39	6–8	15	...	4	3–4	2	3–4	2
Westcott 18	6–8	18	6–8	4	3–4	2	3–4	2
White	12–16	21	12–16	4	12–16	2	12–16	4
Willys Six 89	6–8	16	...	..	†3–4	2	†3–4	2
Willys-Knight	6–8	16	...	..	†3–4	2	†3–4	2
Willys-Knight	6–8	16	...	..	3–4	2	3–4	2
Winton 33	6–8	15	...	..	6–8	2	6–8	2
Winton 48	6–8	15	...	..	6–8	2	6–8	2
Woods Dual 54	...	..	...	..	...	..	...	..
Yale M	...	..	...	..	...	..	...	..

and Lighting: Auto-L, Auto-Lite: G & D, Gray & Davis; Leece-N, Leece-Leonard; West, Westinghouse. Wiring: Sing, Single; Dbl, Double. Igni-Magneto. Spark Plug: Met, metrical.

Electrical Equipment

FOR LAMP, SPARK PLUG AND

MAKE and MODEL OF CAR	SYSTEM	IGNITION		GENERATOR		MOTOR	
		Make	Control	Make	Voltage	Make	Voltage
Allen 41......	Single	Conn.	Hand	A-L	6	A-L	6
American B...	Single	At Kent.	Hand	West	6	West	6
Anderson, All..	Single	Conn.	Hand	West	6	West	6
Apperson 8-19.	Single	Remy	Hand	Bijur	6	Bijur	6-8
Auburn 6-39...	Single	Remy	Hand	Remy	6	Remy	6
Austin 12.....	Single	Delco	.....	Delco	6	Delco	6
Biddle H......	Single	Eisemann	Hand	G & D	6	G & D	6
Birch	Single	Conn.	.....	A-L	6	A-L	6
Brewster	Single	Conn.	.....	A-L	6	A-L	6
Briscoe 4-24...	Single	Conn.	Hand	A-L	6	A-L	6
Buick	Single	Delco	Hand	Delco	6	Delco	6
Cadillac 57....	Single	Delco	Hand	Delco	6	Delco	6
Campbell C-4..	Single	At-Kent.	.....	A-L	..	....	..
Case U-19.....	Single	West	Hand	West	6	West	6
Chalmers 35C..	Single	Bosch-Rem.	Hand	West	6	West	6
Chandler	Single	Bosch	Hand	West	6	West	6
Chevrolet, All..	Single	Remy	Hand	A-L	6	A-L	6
Cole 870......	Dual	Delco	H & A	Delco	6	Delco	6
Columbia, All..	Single	At-Kent.	Hand	Ward-L	6	Ward-L	6
Comet C-51....	Single	Delco	H & A	Dyneto	6	Dyneto	6
Crow-Elkhart K-36........	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Cunningham V-3.........	Single	Delco	Hand	West	6	West	6
Daniels 8-B....	Single	West	Hand	West	6	West	6
Davis		Bosch	.....	West	6	West	6
Dixie Flyer....	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Dodge	Single	....	H & A	North East	12	North East	..
Dorris	Single	....	Hand	West	6	West	..
Dort 15.......	Single	Conn.	Hand	West	6	West	6
Elcar, All.....	Single	At-Kent.	Hand	Dyneto	7	Dyneto	6
Elgin H......	Single	Wagner	Hand	....	..	....	..
Essex A.......	Single	Delco	H & A	Delco	7	Delco	6
Ford T*.......	Single	Own	Hand	Own	..	Own	6
Franklin 9....	Single	At-Kent.	Auto	Dyneto	12	....	..
Geronimo		Delco	.....	Dyneto	6	Dyneto	6
Glide 6-40.........		West	.....	West	6	West	6
Harroun	Single	At-Kent.	Hand	Remy	6	Remy	6
Harvard 4-20.......		At-Kent.	.....	Wagner	6	Wagner	6
Hatfield A..........		Conn.	.....	Dyneto	6	Dyneto	6
Haynes, All....	Single	Delco	Auto	Leece-N	6	Leece-N	6
Hollier, All....	Single	At-Kent.	Hand	Splitdorf	6	Splitdorf	12
Holmes	Single	Eisemann	Auto	Dyneto	12	....	..
Hudson Super Six.........	Dual	Delco	Hand	Delco	7	Delco	7
Hupmobile R..	Single	At-Kent.	Hand	West	7	West	7
Jackson	Single	Remy	S-A	....	..	....	..
Jones	Single	Remy	Hand	West	6	West	6
Jordan	Single	Delco	H & A	Bijur	6	Bijur	6
King 8........	Single	At-Kent.	H & A	Bijur	6	Bijur	6
Kissel	Single	Remy	Hand	Remy	6	Remy	6
Kline 642-S8...	Single	Conn.	Hand	West	6	West	6
Lexington R-19.	Single	Conn.	Hand	West	6	West	6
Liberty 10B...	Dual	Delco	Hand	Delco	6	Delco	6
Locomobile 38-2	Dual	Berling	Hand	West	6	West	6
Maibohm B....	Single	At-Kent.	Hand	Wagner	6	Wagner	6
Marmon 34....	Single	Bosch	Hand	Bijur	6	Bijur	6
Maxwell 25....	Single	......	Hand	Simms-Huff	12	Simms-Huff	12
McFarlan 127..	Double	Bosch	Hand	West	6	West	6
[illegible] Ser. 4..	Single	Berling	Hand	Remy	6	Remy	6

of 1919 Cars

HORN EQUIPMENT, see pages 558 and 559

	BATTERY			Wiring System	Type of Electric System	FUSES		
MAKE and MODEL OF CAR	Make	Amp. Hr.	Voltage			Type	Volts	Amp
Allen 41	U. S. L	90	6	1	GI	GT	5	15
American B	Columbia	80	6	1	S	3-A	1.250	20
Anderson, All	Willard	.....	6.	1	S	SAE	6	5
Apperson 8-19	Willard	90	6	1	S	Open	1.250	10
Auburn 639	Willard	80	6	1	S	......	6-8	25
Austin 12	Willard	.....	6	1	S	None	.....	..
Biddle H	Willard	90	6	1	S	GT	6	10
Birch	Willard	80	6	1	S	GT	6	20
Brewster	.....	.....	..	..	..	......	.....	..
Briscoe 4-24	U. S. L	80	6	1	GI	GT	6	15
Buick	U. S. L	80	6	1	S	......	.....	..
Cadillac 57	Exide	.....	6	..	..	......	.....	..
Campbell C-4	Willard	.....	..	1	..	......	.....	..
Case U-19	Willard	117½	6	1	GI	3AGT	50	15
Chalmers 35C	Willard	93	..	1	..	......	.....	..
Chandler	Willard	100	6	1	S	Cart	6	20
Chevrolet, All	Willard	80	6	1	GI	GT	6	20
Cole 870	Prest-O-L	50	6	1	S	......	.....	..
Columbia, All	Prest-O-L	80	6	..	S	......	.....	..
Comet C-51	Willard	75	6	..	..	......	.....	..
Crow-Elkhart K-36	Willard	.....	6	1	..	......	.....	..
Cunningham V-8	Willard	120	..	1	..	......	.....	..
Daniels 8-B	Willard	100	..	1	S	GT	5-8	15
Davis	Willard	.....	..	..	..	......	.....	..
Dixie Flyer	Willard	6-60	..	2	..	......	.....	..
Dodge	Willard	.....	12	1	GM	Encl.	1-50	10
Dorris	Willard	115	6	1	S	GT	5-8	15
Dort 15	Willard	85	6	1	S	......	6	10
Elcar, All	Willard	90	6	1	..	......	.....	..
Elgin H	Willard	90	..	1	..	......	.....	..
Essex A	.....	105	6	1	S	......	.....	..
Ford T*	Exide	30	6	1	S	......	.....	..
Franklin 9	Willard	50	12	..	GM	GT	122	15
Geronimo	Willard	88	6	1	S	......	.....	..
Glide 6-40	Willard	80	6	1	GI	Cart	250	15
Harroun	Willard	80	6	1	..	......	.....	..
Harvard 4-20	Nat.C'rb.	.....	..	1	S	......	.....	..
Hatfield A	Willard	100	6	1	GI	......	.....	..
Haynes, All	Willard	120	6	2	GI	C. B.	.....	..
Hollier, All	Gould	50	6	1	GM	......	.....	..
Holmes	Columbia	100	12	2	S	2A	15	15
Hudson Super Six	Exide	100	6	1	GM	......	.....	..
Hupmobile R	Willard	87½	6	1	S	Encl.	6	10
Jackson	Prest-O-L	120	6	2	S	3A	6-8	20
Jones	Prest-O-L	120	6	1	..	......	.....	..
Jordan	Willard	109.8	6	1	S	C. B	.....	..
King 8	Willard	117.5	6	1	..	......	.....	..
Kissel	Willard	90	6	1	S	3 A. G	.....	20
Kline 642-88	Prest-O-L	80	6	1	S	5 A. G.	6	..
Lexington R-19	Willard	100	6	1	S	G. T.	6	..
Liberty 10B	Willard	88	6	1	GI	......	.....	..
Locomobile 38-2	Willard	120	6	1	S	G. T.	6	10
Maibohm B	Willard	80	6	1	S	A 1	6	30
Marmon 34	Pest-O-L.	120	6	1	S	Cart	...	20
Maxwell 25	Prest-O-L	35	12	1	GM	Cart	12	20
McFarlan 127	Willard	5 Amp. 27.8 h.p.	6	1	GI	5 A. G.	6	..
Mercer, Ser. 4	Willard	90	6	1	S	Cart	...	10

Electrical Equipment

FOR LAMP, SPARK PLUG AND

MAKE and MODEL OF CAR	IGNITION SYSTEM	IGNITION Make	Control	GENERATOR Make	GENERATOR Voltage	MOTOR Make	MOTOR Voltage
Mitchell E-40..	Single	Remy	Hand	Remy	6	Remy	6
Moline K'gt L.	Dual	Con.	Hand	Wagner	6	Auto-Lite	6
Monitor	Single	......	Hand	Dyneto	6	Dyneto	..
Moon, all.....	Single	Delco	Auto	Wagner	6	Wagner	6
Moore 30.....	Single	Conn.	Hand	A L	6	A L	6
Nash	Single	Delco	H & A	Delco	6	Delco	6
National 6....	Single	Delco	H & A	West	6	West	6
National 12...	Single	Delco	H & A	Bijur	6	Bijur	6
Oakland 34-B..	Single	......	Hand	Remy	6	Remy	6
Oldsmobile, all.	Single	Remy	Hand	Delco	6	Delco	6
Olympian 45..	Single	Conn.	Hand	A L	6–8	A L	6
Overland 90...	Single	Conn.	Hand	A-L	6	A-L	6
Packard 3-25..	Single	Delco	H & A	Bijur	6	Bijur	6
Paige, all.....	Single	Remy	Hand	Gray & Davis	6	Gray & Davis	6
Paterson 6-46 .	Dual	Delco	Hand	Delco	6	Delco	6
Peerless Ser 4.	Single	At-Kent	H & A	AL	6	A L	6
Pierce-A'w B-5.	Double	Bosch	Hand	West	6–8	West	6
Pilot 6-45.....	Dual	Delco	Hand	Delco	6	Delco	6
Premier 6-C...	Single	Delco	Hand	Delco	6	Delco	6
Reo T & U....	Single	Remy	Hand	Remy	6	Remy	6
Revere	Single	Bosch	Hand	North East	6	North East	6
Roamer 6-54..	Single	Bosch	Hand	Bijur	6	Bijur	6
Saxon Y-16...	Single	Remy	Hand	Wagner	6	Wagner	6
Sayers	Single	Delco	.....	Delco	6	Delco	6
Scripps-Booth .	Single	Remy	Hand	Remy	..	Remy	6
Seneca H.....	Single	......	Hand	Allis-Chalm.	6	....	..
Singer "19"...	Single	Bosch	Hand	West	6	West	6
Standard 8 G..	Single	Split	Hand	West	6	West	6
Stanley 735........		......	.....	Remy	6	....	..
Stearns SKL-4.	Single	Remy	Hand	Remy	12	Remy	12
Stephens 76...	Single	Delco	Hand	Delco	6	Delco	6
Studebaker EH.	Single	Remy	Hand	Wagner	6–8	Wagner	6
Stutz G	Double	......	Hand	Remy	6	Remy	6
Templar 445..	Single	Remy	H & A	Remy	6–8	Remy	6
Tulsa A-D-1...	Single	Delco	Hand	Dyneto	6	Dyneto	6
Velie 38......	Single	Remy	Auto	Remy	6	Remy	6
Westcott	Single	Delco	H & A	Delco	6	Delco	6
Willys-Knight 88-4.......	Single	Conn.	Hand	A-L	6–8	A-L	6
Winton Six, all.	Single	Bosch	Hand	Bijur	6	Bijur	6

LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE

MAKE and MODEL OF CAR	Contact	LIGHTS Volts	LIGHTS CP.	LIGHTS lVots	LIGHTS CP.	LIGHTS Volts	LIGHTS CP.	LIGHTS Volts	LIGHTS CP.
Allen 41.........	Single	6–8	18	*6–8	4	6–8	2	6–8	2
American B......	Single	6–8	15	*6–8	4	6–8	2	d6–8	2
Anderson, all.....	Single	6–8	12	6–8	2	6–8	2	6–8	2
Apperson 8-19....	Single	6–8	15	*6–8	4	6–8	2	d6–8	2
Auburn 6-39......	Single	6–8	15	*6–8	4	6–8	2	d6–8	2
Austin 12........	Single	6–8	24	6–8	16	6–8	6	6–8	3
Biddle H.........	Single	6–8	18	*6–8	4	6–8	2	d6–8	4
Birch	Double	6–8	15	*6–8	4	6–8	4	6–8	4
Brewster		...	..	...	..	...	..	...	..
Briscoe 4-24......	Single	6–8	21	...	..	6–8	4	d6–8	4
Buick	Single	6–8	16	...	..	6–8	8	6–8	8
Cadillac 57...............		6–8	18	6–8	6	3–4	2	3–4	2
Campbell C-4.............		...	..	...	..	6–8	..	...	..
Case U-19........	Single	6–8	18	6–8	4	6–8	2	d6–8	2
Chalmers 35-C....	Single	6–8	15	6–8	4	6–8	2	6–8	2

of 1919 Cars—Continued

HORN EQUIPMENT, see pages 558 and 559

MAKE and MODEL OF CAR	BATTERY Make	BATTERY Amp. Hr.	BATTERY Voltage	Wiring System	Type of Electric System	FUSES Type	FUSES Volts	FUSES Amp
Mitchell E-40	Willard	100	6	2	GM	Cart	6	20
Moline Knight L	Willard	117	6	1	S	Cart	250	20
Monitor	Willard	88	6	1	..	....	...	..
Moon, all	Exide	80	6	1	..	....	...	..
Moore 30	Willard	80	6	2	..	....	...	..
Nash	Willard	100	6	1	S	....	...	..
National 6	Prest-O-L	110	6	1	S	G	...	5
National 12	Prest-O-L	110	6	1	S	G	...	10
Oakland 34-B	Prest-O-L	85	6	1	GI	....	...	..
Oldsmobile, all	U. S. L.	80	6	1	..	....	...	..
Olympian 45	U. S.	.....	6	..	..	....	...	..
Overland 90	U. S. L.	75	6–8	..	GI	Glass	6	20
Packard 3-25	Willard	120	6	1	S	G. T.	6	10
Paige, all	Willard	108.4	6	1	S	G	...	20
Paterson 6-46	Willard	.....	6	1	..	....	...	..
Peerless, Ser. 4	Willard	.....	6	1				
Pierce-Arrow B-5	Exide-Willard	135	6	1	..	5 A. G.	6–8	10
Pilot 6-45	Prest-O-L	....	6	1	GI	....	...	..
Premier 6-C	Willard	123.5	6	1	S	....	...	..
Reo T & U	Willard	108.5	6	2	GI	Wire	6	5
Revere	Willard	120	6	1	S	....	...	..
Roamer 6-54	Willard	115	6	1	S	3A	6	10
Saxon Y-16	Prest-O L	60	6	1	S	Cart	6–8	15
Sayers	Willard	.....	6	1	..	....	...	..
Scripps-Booth	Prest-O-L	80	6	1	..	....	...	..
Seneca H	Willard	88	6	1	GM	....	...	20
Singer "19"	Willard	115	6	1	S	G. C.	...	5&10
Standard 8 G	Willard	160	6	1	..	....	...	..
Stanley 735	Willard	100	6	1	G	Cart	6	20
Stearns SKL-4	Willard	61.5	12	1	S	....	...	20
Stephens 76	Willard	80	6	1	S	....	...	20
Studebaker EH	Willard	80	6	1	S	Cart	6	10
Stutz G	Willard	.....	12	2	..	....	...	..
Templar 445	Columbia	100	..	1	..	....	...	..
Tulsa A-D-1	Willard	90	6	1	S	G. T.	6	15
Velie 38	Willard	105	6	1	S	Wire	6	5
Westcott	Willard	109.8	6	1	S	C. B.	7	25
Willys-Knight 88-4	U. S. L	120	6	2	GI	G. T.	6	20
Winton Six, all	Willard	110	6	1	S	3A	6	20

MAKE and MODEL OF CAR	SPARK PLUGS Make	SPARK PLUGS Diam. Inches	SPARK PLUGS Thread Pitch	HORN
Allen 41	Champion	⅞	18	Garford
American B		⅞	18	Sparton
Anderson, all	A. C.	⅞	18	Klaxon
Apperson 8-19	A. C.	⅞	18	Sparton
Auburn 6–39	Rajah	⅞	18	E. A.
Austin 12	Reflex	⅞	18	Sparton
Biddle H	Splitdorf	⅞	18	Klaxon
Birch		⅞	18	....
Brewster	Herz-Boug.	⅞	18	Klaxon
Briscoe 4-24	Champion	⅞	..	Schwarze
Buick	A. C.	⅞	18	Stewart
Cadillac 57	Titan	..	..	Auto-horn
Campbell C-4	A. C.	..	..	Garford
Case U-19	A. C.	⅞	..	Klaxon
Chalmers 35-C	A. C.	..	..	Sparton

Electrical Equipment

FOR IGNITION, GENERATOR, MOTOR,

MAKE and MODEL OF CAR	Contact	LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE							
		HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
		Volts	CP.	lVots	CP.	Volts	CP.	Volts	CP.
Chandler	Single	6–8	16	6–8	4	6–8	2	6–8	2
Chevrolet, all	Single	6–8	20	6–8	4	6–8	4	6–8	4
Cole 870	Single	6–8	21	*6–8	12	6–8	4	d6–8	6
Columbia, all	Single	6–8	15	*6–8	4	6–8	2	d6–8	2
Comet C-51	Single	6–8	..	3–4	..	3–4	..	3–4	..
Crow-Elkhart K-36		6–8	16	6–8	4	6–8	2	6–8	2
Cunningham V-3		6–8	21	6–8	6	6–8	2	6–8	4
Daniels 8-B	Single	6–8	18	6–8	2	6–8	4	6–8	2
Davis		6–8	18	...	..	6–8	2	6–8	2
Dixie Flyer	Double	6–8	15	...	..	3–4	2	3–4	2
Dodge	Single	12–18	15	...	..	12–18	2	12–18	2
Dorris	Single	6–8	21	*6–8	4	6–8	4	6–8	4
Dort 15	Single	6–8	15	...	..	6–8	4	6–8	2
Elcar, all		6–8	15	6–8	4	5–8	2	6–8	2
Elgin H	Double	6–8	15	...	..	6–8	3	6–8	2
Essex A	Single	6–8	15	...	..	3–4	2	*3–4	2
Ford T		6–8	17	6–8	2	6–8	2	...	..
Franklin 9	Double	12–18	21	*12–8	4	8	2	12–18	2
Geronimo	Single	6–8	21	...	..	6–8	2	6–8	2
Glide 6-40	Single	5–8	15	*6–8	4	6–8	2	d6–8	2
Harroun		6–8	20	...	..	3–4	6	3–4	6
Harvard 4-20		6–8	..	3–4	..	3–4	..	*3–4	..
Hatfield A	Single	6–8	15	*4–8	4	6–8	4	6–8	2
Haynes, all	Double	6–8	18	*6–8	12	6–8	2	6–8	2
Hollier, all	Single	6–8	15	...	..	3–4	2	d*3–4	2
Holmes	Double	12–16	30	*12–16	4	6–8	2	6–8	2
Hudson Super Six	Single	6–8	5	6–8	4	3–4	2	*3–4	2
Hupmobile R	Single	6–8	15	6–8	2	6–8	2	6–8	2
Jackson		...	..	...	..	...	..	...	..
Jones	Double	6–8	15	*6–8	4	s6–8	2	s6–8	2
Jordan	Single	6–8	21	*6–8	4	6–8	3	6–8	3
King 8	Single	6–8	18	*6–8	4	6–8	4	6–8	2
Kissel	Single	6–8	18	*6–8	4	6–8	2	6–8	2
Kline 642 S. 8	Single	6–8	15	...	..	6–8	4	d6–8	4
Lexington R-19	Single	6–8	32	*6–8	8	6–8	2	d6–8	4
Liberty 10B	Single	6–8	15	*6–8	4	6–8	2	6–8	2
Locomobile 38-2	Single	6–8	21	6–8	6	6–8	4	6–8	2
Maibohm B	Single	6–8	16	6–8	4	3–4	2	*3–4	2
Marmon 34	Single	6–8	30	*6–8	9	6–8	2	6–8	4
Maxwell 25	Double	12–16	24	*12–16	2	12–16	2	12–16	2
McFarlan 127	Single	6–8	21	*6–8	12	6–8	2	6–8	2
Mercer, Ser. 4	Single	6–8	24	*6–8	4	6–8	4	6–8	4
Mitchell E-40	Double	6–8	14	...	..	s6–8	4	6–8	4
Moline Knight L		*6–8	15	*6–8	4	6–8	2	6–8	2
Monitor		...	..	...	..	...	..	...	..
Moon, all	Single	6–8	18	...	..	6–8	2	d6–8	2
Moore 30	Single	6–8	20	6–8	..	6–8	2	...	..
Nash	Single	6–8	18	*6–8	4	6–8	2	6–8	2
National 6	Single	6–8	16	*6–8	6	6–8	4	d6–8	2
National 12	Single	6–8	18	*6–8	6	6–8	4	d6–8	2
Oakland 34-B	Single	6–8	..	...	..	6–8	2	6–8	2
Oldsmobile 37-A		6–8	15	...	..	6–8	2	6–8	2
Olympian 45		...	..	...	..	...	..	...	..
Overland 90		6–8	12	...	..	3–4	2	*3–4	2
Packard 3-25	Single	6–8	24	*6–8	4	6–8	2	6–8	2
Paige, all	Single	6–8	18	*6–8	4	6–8	2	d6–8	2
Paterson 6-46		6–8	24	6–8	4	3–4	3	*3–4	3

of 1919 Cars—Continued

BATTERY AND FUSE EQUIPMENT, see pages 554 and 555

MAKE and MODEL OF CAR	SPARK PLUGS			HORN
	Make	Diam. Inches	Thread Pitch	
Chandler	A. C.	⅞	18	Trojan
Chevrolet, all	A. C.	⅞	18	Klaxon
Cole 870	A. C.	⅞	18	Sparton
Columbia, all	Champion	⅞	18	Schwarze
Comet C-51	Champion	⅞	18	Trojan
Crow-Elkhart K-36	Champion	⅞	..	E. A. Lab.
Cunningham V-3	Champion	..	..	Sparton
Daniels 8-B	A. C.	⅝	18	Klaxon
Davis	A. C.	⅞	..	Klaxon
Dixie Flyer	Champion	..	..	Garford
Dodge	A. C.	⅞	18	Klaxon
Dorris	Champion A. C.	⅞	18	Klaxon
Dort 15	A. C.	⅞	18	Schwarze
Elcar, all	Champion	..	..	Klaxon
Elgin H	Champion	⅞	18	E. A. L.
Essex A	A. C.	18 m.m.	15 m.m.	Sparton
Ford T	Champion	½	pipe	Own
Franklin 9	Splitdorf Benton	⅞	18	Klaxon
Geronimo	Champion	⅞	18	Trojan
Glide 6-40	Champion	⅞	18	Klaxon
Harroun	A. C.	..	..	Schwarze
Harvard 4-20		⅞	18	....
Hatfield A	A. C.	⅞	18	Ecco
Haynes, all	A. C.	⅞	18	Klaxon
Hollier, all	Champion	⅞	18	Sparton
Holmes	Bethlehem	⅞	18	Klaxon
Hudson Super Six	A. C.	⅞	18	Sparton
Hupmobile R	A. C.	⅞	18	Trojan
Jackson	A. C.	..	..	....
Jones	Champion	⅞	18	Newtone
Jordan	A. C.	⅞	18	Sparton
King 8	Champion	⅞	18	E. A. L.
Kissel	A. C.	..	..	Sparton
Kline 642 S. 8	Champion	⅞	18	Klaxon
Lexington R-19	Champion Bethlehem	⅞	18	Klaxon
Liberty 10B	A. C.	⅞	18	United
Locomobile 38-2	Champion	⅞	18	Klaxon
Maibohm B	Champion	⅞	18	E. A. Lab.
Marmon 34	A. C.	⅞	18	Sparton
Maxwell 25	Champion	⅞	18	Schwarze
McFarlan 127	A. C.	⅞	18	Klaxon
Mercer Ser. 4	Champion	⅞	18	Sparton
Mitchell E-40	A. C.	⅞	18	A. E. L.
Moline Knight L	A. C.	⅞	18	Klaxon
Monitor	Champion	⅞	18	Klaxon
Moon, all	Champion	⅞	18	Trojan
Moore 30	Champion	⅞	18	Garford
Nash	A. C.	⅞	18	Stewart
National 6	A. C.	⅞	18	Sparton
National 12	A. C.	⅞	18	Trojan
Oakland 34-B	A. C.	⅞	18	Klaxon
Oldsmobile 37-A	A. C.	⅞	18	Optional
Olympian 45	Champion	..	..	E. A. Lab.
Overland 90	Champion	½	..	Auto-Lite
Packard 3-25	A. C.	⅞	18	Sparton
Paige, all	A. C.	..	..	Trojan
Paterson 6-46	A. C.	..	..	E. A. Lab.

Electrical Equipment

FOR IGNITION, GENERATOR, MOTOR,

		LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE							
		HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
MAKE and MODEL OF CAR	Contact	Volts	CP.	lVots	CP.	Volts	CP.	Volts	CP.
Peerless, Ser. 4	Single	6–8	18	...	..	6–8	4	6–8	2
Pierce-Arrow 5	Single	6–8	21	*6–8	4	6–8	4	6–8	4
Pilot 6-45	Single	6–8	15	...	..	6–8	6	6–8	6
Premier 6-C	Double	6–8	21	*6–8	4	6–8	2	6–8	2
Reo T & U	Double	6–8	15	...	..	3–4	2	*3–4	2
Revere	Double	6–8	20	*6–8	8	6–8	4	6–8	4
Roamer 6-54	Single	6–8	16	*6–8	4	6–8	4	d6–8	4
Saxon Y-16	Single	6–8	15	...	..	6–8	2	6–8	2
Sayers	Single	6–8	15	...	..	6–8	2	d6–8	2
Scripps-Booth	Single	6–8	15	...	..	6–8	2	6–8	2
Seneca II	Single	6–8	15	6–8	2	6–8	2	d6–8	2
Singer "19"	Double	6–8	32	6–8	4	6–8	2	6–8	2
Standard 8-G	Single	6–8	32	*6–8	4	6–8	2	6–8	2
Stanley 735	Single	6–8	18	*6–8	2–4–6	6–8	2	6–8	2
Stearns SKL-4	Single	12–16	12	*12–16	4	12–16	2	12–16	2
Stephens 76	Single	6–8	15	6–8	2	6–8	2	6–8	2
Studebaker EH	Single	6–8	12	...	..	6–8	2	6–8	2
Stutz G		...	15	*	4	...	4	...	4
Templar 445	Single	6–8	18	*6–8	4	6–8	2	6–8	2
Tulsa A-D-1	Single	6–8	21	6–8	2	6–8	2	d6–8	2
Velie 38	Single	6–8	15	*6–8	4	6–8	4	d6–8	4
Westcott	Single	6–8	15	*6–8	4	d3–4	2	d*3–4	2
Willys-Knight 88-7.4	S-D-2	6–8	16	...	..	3–4	2	*3–4	2
Winton Six 22	Single	6–8	21	6–8	12	6–8	4	6–8	4

ABBREVIATIONS: * Starting and Lighting in closed models only. Ignition: *At-K*, Atwater-Kent; *Conn.*, Connecticut; *West*, Westinghouse; *Auto*, Automatic; *H & A*, Hand and Automatic; *S. A.*, Semi-Automatic. Generator: *A-L*, Auto-Lite; *G & D*, Gray & Davis; *Leece-N*, Leece-Neville; *Ward-L*, Ward-Leonard; *West*, Westinghouse; *N. E.*, North East; *Split*, Splitdorf. Motor: *A-L*, Auto-Lite; *G & D*, Gray & Davis; *Leece-N*, Leece-

of 1919 Cars—Concluded

BATTERY AND FUSE EQUIPMENT see pages 554 and 555

MAKE and MODEL OF CAR	SPARK PLUGS Make	Diam. Inches	Thread Pitch	HORN
Peerless Ser. 4	A. C	..	..	Sparton
Pierce-Arrow 5	A. C	⅞	18	Klaxon
Pilot 6-45	A. C	⅞	18	Schwarze
Premier 6-C	A. C	⅞	18	Stewart
Reo T & U	A. C	⅞	18	Trojan Klaxon
Revere	Rajah	⅞	..	Klaxon
Roamer 6-54	Champion	⅞	18	Sparton
Saxon Y-16	A. C	⅞	18	Schwarze
Sayers	Champion	..	..	Stewart
Scripps Booth	A. C	..	..	Trojan Klaxon
Seneca H	A. C	⅞	18	Fitzgerald
Singer "19"	A. C	..	..	Klaxon
Standard 8-G	Splitdorf	⅞	18	Klaxon
Stanley 735		..	..	Klaxon
Stearns SKL-4	A. C	⅞	18	B. & A. Lab.
Stephens 76	Champion	..	..	Trojan
Studebaker EH	Champion	½	..	Sparton
Stutz G	A. C	..	..	Klaxon
Templar 445	Champion	⅞	..	• Schwarze
Tulsa A-D-1	Champion	⅞	18	Klaxon
Velie 38	Champion	⅞	18	Sparton
Westcott	A. C	⅞	18	Klaxon
Winton Six 22	Champion	⅞	18	Klaxon A. L.
Willys Knight 88-7	Champion	⅞	18	American Electric

Neville; *West*, Westinghouse. Battery: *Prest-O-L*, Prest-O-Lite. Wiring system: *GI*, Generator and Ignition combined; *GIM*, Generator, Ignition, Motor combined; *S*, Generator, Motor, Ignition separate; *GM*, Generator and Motor combined. Fuses: *GT*, Glass Tube; *Cart*, Cartridge; *C. B.*, Circuit Breaker. Lamps: * Dashlights in series with taillights; headlight contains sidelight; d,—double contact; s,—single contact.

Electrical Equipment

· FOR LAMP, SPARK PLUG AND

MAKE and MODEL OF CAR	IGNITION			GENERATOR		MOTOR	
	SYSTEM	Make	Control	Make	Voltage	Make	Voltage
Allen, 43	Single	Conn.	Hand	A-L	6	A-L	6
American B	Single	Conn.	Hand	West	6	Remy	6
Anderson, All	Single	Remy	Hand	Remy	6	West	6
Apperson, All	Single	Remy	Hand	Bijur	6	Bijur	6-8
Argonne, 4	....	Eise.	Hand	West	12	West	12
Auburn, 6-39	Single	Remy	Hand	Remy	6	Remy	6
Beggs	....	Conn.	Hand	A-L	6	A-L	6
Biddle, B-1 & B-5	Single	Simms	Hand	G & D	6	G & D	6
Bour-Davis, 20	Single	Remy	Hand	Remy	6	Remy	6
Brewster	Single	Berling	Hand	U. S. L.	12	U. S. L.	12
Briscoe, 4-34	Single	Conn.	Nand	A-L	6	A-L	6
Buick	Single	Delco	Hand	Delco	6	Delco	6
Cadillac, 57	Single	Delco	H & A	Delco	6	Delco	6
Case, V	Single	West	H & A	West	6	West	6
Chalmers, 35-C	Single	Remy	Hand	A-L	6	A-L	6
Champion	Single	Delco	Hand	Dyneto	6	Dyneto	6
Chandler, All	Single	Bosch	Hand	G & D	6	G & D	6
Chevrolet, All	Single	Remy	Hand	A-L	6	A-L	6
Cleveland, 40	Single	G. & D.	Hand	G & D	6	G & D	6
Cole, All	Eingle	Delco	H & A	Delco	6	Delco	6
Columbia	Single	At-Kent.	Hand	A-L	6	A-L	6
Comet, C-53	Single	Wagner	Hand	Wagner	6	Wagner	6
Commonwealth	Single	At-Kent.	Hand	Dyneto	6	Dyneto	6
Crow-Elkhart, L-55	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Crow-Elkhart H-55	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Cunningham V-3	Single	Delco	H & A	West	6	West	6
Daniels, D	Single	Delco	H & A	Delco	6	Delco	6
Davis, 51	Single	Bosch	Hand	Delco	6	Delco	6
Dixie Flyer	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Dodge Bros	Single	Own	H & A	North East	12	North East	12
Dorris, 6-80	Single	Bosch	Hand	West	6	West	6
Dort, 15	Single	Conn.	Hand	West	6	West	6
du Pont, A	Single	....	H & A	West	6	West	6
Economy, 6-46	Single	Own	Hand	A-L	6	A-L	6
Elear, All	Single	Delco	Hand	Delco	6	Delco	6
Elgin, K	Single	Wagner	Hand	Wagner	6	Wagner	6
Essex, A	Single	Delco	H & A	Delco	7	Delco	6
Ferris	....	....	....	L-N	....	L-N	....
Ford, T*	Single	Own	Hand	Own	6	Own	—
Franklin	....	....	....	....	....	....	....
Gardner, O	Single	West	Hand	West	6	West	6
Geronimo	....	Delco	....	Dyneto	6	Dyneto	6
Grant, H	Single	At-Kent.	Hand	Bijur	6	Grant-W	6
Hanson	Single	Remy	Hand	A-L	6	A-L	6
Harroun, A A-2	Single	Remy	Hand	Remy	6	Remy	6
Harvard, 4-20	....	At-Kent.	....	Wagner	6	Wagner	6
Hatfield, A	....	Conn.	....	Dyneto	6	Dyneto	6

of 1920 Cars

HORN EQUIPMENT, see pages 558 and 559

MAKE and MODEL OF CAR	BATTERY			Wiring System	Type of Electric System	FUSES		
	Make	Amp. Hr.	Voltage			Type	Volts	Amp
Allen, 43	Prest-O-L	80	6	1	GI	GT	6	15
American, B	Willard	90	6	1	S	3-A	1.250	20
Anderson, All	Willard	90	6	1	S	SAE	6	5
Apperson, All	Willard	108	7	1	S	Open	1.250	10
Argonne, 4	Exide	100	12	1	....	....	12	20
Auburn, 6-39	Willard	80	6	1	S	....	6-8	25
Beggs	Exide	80	6	1	GT	Cart.	6	15
Biddle, B-1 & B-5	Willard	90	6	1	S	GT	6	10
Bour-Davis, 20	Willard	103	6	1	S	GT	6	15
Brewster	....	......	....	....	....	....	......	....
Briscoe, 4-34	Prest-O-L	80	6	1	GI	GT	6	20
Buick	Willard	80	6	1	S	....	......	....
Cadillac, 57	Exide	130	6	1	GM	....	......	....
Case, V	Willard	117½	6	1	GI	5AGT	50	105
Chalmers, 35-C	Prest-O-L	105	6	1		....	6	151
Champion	Willard	90	6	1	S	GT	6	200
Chandler, All	Prest-O-L	105	6	1	S	GT	6	....
Chevrolet, All	Willard	80	6	1	GI	GT	6	....
Cleveland, 40	Prest-O-L	94	6	1	S	GT	6	....
Cole, All	Prest-O-L	50	6	1	S	....	......	....
Columbia	Prest-O-L	80	6	1	S	....	......	....
Comet, C-53	Willard	75	6	1	....	....	......	....
Commonwealth	Prest-O-L	105	6	....	....	....	......	....
Crow-Elkhart, L-55	Exide	120	6	1	....	Cart.	6	10
Crow-Elkhart, H-55	Exide	......	6	1	....	....	......	....
Cunningham, V-3	Willard	120	6	1	....	....	......	....
Daniels, D	Willard	140	6	1	S	....	......	....
Davis, 51	Willard	90	6	1	S	....	......	....
Dixie Flyer	Willard	6-80	....	2	....	....	......	....
Dodge Brothers	Willard	50	12	1	GM	Encl.	1-50	10
Dorris, 6-80	Willard	115	6	1	S	GT	5-8	15
Dort, 15	U. S. L.	85	6	1	S	....	6	10
duPont, A	Exide	115	6	1	....	....	......	....
Economy, 6-46	Willard	90	6	....	....	....	......	....
Elcar, All	Willard	90	6	1	S	GT	6-8	20
Elgin, K	Willard	90	6	1	....	GT	6-8	20
Essex, A	Exide	105	6	1	S	....	......	....
Ferris	....	......	....	....	....	....	......	....
Ford, T	Opt.	80	6	1	S	....	......	....
Gardner, O	Willard	90	6	1	S	GT	6	20
Geronimo	Willard	88	6	1	S	....	......	....
Grant, H	Prest-O-L	106	6	1	S	2GT	6-8	15
Hanson	Prest-O-L	80	6	1	....	Cart.	6	3
Harroun	Prest-O-L	80	6	1	....	....	......	....
Nat. Carb	Nat. Carb	......	....	1	S	....	......	....
Hatfield, A	Willard	100	6	1	GI	....	......	....

Electrical Equipment

FOR LAMP, SPARK PLUG AND

MAKE and MODEL OF CAR	SYSTEM	IGNITION		GENERATOR		MOTOR	
		Make	Control	Make	Voltage	Make	Voltage
Haynes, All	Single	Opt.	Hand	Luce-N	6	Luce-N	6
H. C. S. Special	....	Delco	....	Delco		Delco	....
Hollier, 206-B	Single	R. & B.	Hand	West	12	West	6
Holmes	Single	Eise.	Auto	Dyneto	12	....	....
Hudson, O	Single	Delco	H & A	Delco	7	Delco	7
Huffman, W	Single	Conn.	Hand	Dyneto	6	Dyneto	6
Hupmobile, R	Single	At-Kent.	Hand	West	6	West	6
Jackson, 6-38	Single	Remy	Hand	A-L	6	A-L	6
Jones, All	Single	Remy	Hand	A-L	6	A-L	6
Jordan, F	Single	Delco	Hand	Delco	6	Delco	6
Jordan, M	Single	Delco	Hand	Delco	6	Delco	6
Kenworthy	....	....	....	....	....	....	....
King, H	Single	At-Kent.	Hand	West	6	West	6
Kissel	Single	Remy	Hand	Remy	6	Remy	6
Kline, 6-55-J	Single	Conn.	Hand	Wagner	6	Wagner	6
La Fayette	Double	Delco	H & A	Delco	6	Delco	6
Leach	....	Remy	....	West	....	....	....
Lexington, S-20	Single	Conn.	Hand	G & D	6	G & D	6
Liberty, 10-C	Single	Wagner	Hand	Wagner	6	Wagner	6
Locomobile, 48	Dual	Berling	Hand	West	6	West	6
Lorraine	Single	West	Hand	West	6	West	6
Maibohm, B	Single	At-Kent.	Hand	Bijur	6	Bijur	6
Marmon, 34	Single	Delco	Auto	Delco	6	Delco	6
Marshall	....	....	....	....	....	....	....
Martin-Wasp	....	....	....	....	....	....	....
Maxwell, 25	Single	At-Kent.	Hand	Simms-Huff	12	Simms-Huff	12
McFarlan, 127	Double	Opt.	Hand	West	6	West	6
Mercer, Ser. 5	Single	Berling	Hand	West	6	West	6
Meteor, KR	Single	Simms	Hand	Bijur	6	Bijur	6
Metz, Master Six	Single	Conn.	Hand	West	6	West	6
Mitchell, F-40	Single	Remy	Hand	Remy	6	Remy	6
Monitor	Single	Conn.	Hand	Dyneto	6	Dyneto	....
Monroe, S-9	Single	Conn.	Hand	A-L	6	A-L	6
Moon, 6-48	Single	Wagner	Auto	Delco	6	Delco	6
Moon, 6-68	Single	Delco	Auto	Delco	6	Delco	6
Moore, F	Single	Conn.	Hand	A-L	6	A-L	6
Murray	....	....	....	....	....	....	....
Nash	Single	Wagner	H & A	Delco	6	Wagner	6
National, Series	Single	Delco	H & A	West	6	West	6
Nelson, D	Single	Bosch	Hand	U. S. L.	12	U. S. L.	12
Noma, 1-B	Single	Delco	Auto	Delco	6	Delco	6
Oakland, 34-B	Single	Remy	Hand	Remy	6-8	Remy	6
Ogren, 6-60	Single	Bosch	Hand	West	6	West	6
Oldsmobile, 37-A	Single	Remy	Hand	Remy	6	Willard	6
Oldsmobile, 45-B.	Single	Delco	Hand	Delco	6	Delco	6
Overland, 4	Single	Conn.	Hand	A-L	6-8	A-L	6
Packard, 3-35	Single	Delco	H & A	Bijur	6	Bijur	6
Paige, All	Single	At-Kent.	H & A	G & D	6	G & D	6
Pan-American, All	Single	At-Kent.	Hand	West	6	West	6
Parenti	....	....	....	....	....	....	....
Paterson, 6-47	Dual	Delco	Hand	Delco	6	Delco	6

of 1920 Cars—Continued

HORN EQUIPMENT, see pages 558 and 559

MAKE and MODEL OF CAR	BATTERY Make	BATTERY Amp. Hr.	BATTERY Voltage	Wiring System	Type of Electric System	FUSES Type	FUSES Volts	FUSES Amp
Haynes, All	Willard	120	6	1	GI	GT	6	5
H. C. S. Special	....	....	....	....	....	....	....	....
Hollier, 206-B	U. S. L.	80	6	1	S	GT	6	20
Holmes	Willard	100	12	2	S	GT	15	15
Hudson, O	Exide	105	7	1	GM	....	....	....
Huffman, W	Willard	80	6	1	S	....	6	25
Hupmobile, R	Willard	87½	6	1	S	Encl.	6	10
Jackson, 6-38	U. S. L.	94	6	1	GI	GT	6-8	15
Jones, All	Prest-O-L	120	6	1	GI	GT	6	20
Jordan, F	Willard	108	6	1	S	C. B.	....	....
Jordan, M	Willard	94	6	1	S	C. B.	....	....
King, H	Prest-O-L	120	6	1	S	Cart.	6	10
Kissel	Willard	117.5	6	1	S	3A.G.	6	20
Kline, 6-55-J	Prest-O-L	80	6	1	S	5A.G.	6	....
La Fayette	Exide	120	6	1	GM	....	6	....
Leach	....	....	....	....	....	....	....	....
Lexington, S-20	Willard	100	6	1	....	GT	6	15-5
Liberty, 10-C	Willard	90	6	1	GI	....	....	....
Locomobile, 48	Exide	150	6	1	S	GT	6	10
Lorraine	U. S. L.	94	7	1	S	GT	....	....
Maibohm, B	Willard	94	6	1	S	2A	6	20
Marmon, 34	Willard	162	6	1	GI	Cart.	....	....
Maxwell, 25	Prest-O-L	35	12	1	GM	Cart.	....	10
McFarlan, 127	Willard	....	6	1	GI	5A.G.	6	....
Mercer, Ser. 5	Willard	90	6	1	S	Cart.	....	....
Meteor, KR	Willard	....	6	....	....	....	....	....
Metz, Master Six	Willard	120	6	....	....	....	....	....
Mitchell, F-40	Willard	100	6	1	S	GT	6	10
Monitor	Prest-O-L	110	6	1	....	....	....	....
Monroe, S-9	U. S. L.	80	6	1	....	....	....	....
Moon, 6-48	Exide	120	6	1	S	....	....	....
Moon, 6-68	Exide	120	6	1	S	....	....	....
Moore, F	Willard	80	6	2	....	....	....	....
Nash	Willard	100	6	1	S	....	....	....
National, Series BB	Prest-O-L	110	6	1	S	GT	6-8	5
Nelson, D	Willard	72	12	2	S	G	12	5-30
Noma, 1-B	Willard	104	6	....	....	....	....	....
Oakland, 34-B	Prest-O-L	85	6-8	1	GI	....	....	....
Ogren, 6-60	Willard	120	6	1	....	Cart.	6	10
Oldsmobile, 37-A	Remy	80	6	1	....	....	....	....
Oldsmobile, 45-B	Willard	80	6	1	....	....	....	....
Overland, 4	U. S. L.	80	6-8	1	GI	Glass	6	20
Packard, 3-35	Willard	120	6	1	S	GT	6	10
Paige, All	Willard	108.4	6	1	S	G	....	20
Pan-American, All	Willard	100	6	1	S	G	6	....
Paterson, 6-47	Willard	110	6	1	....	....	....	....

Electrical Equipment

FOR LAMP, SPARK PLUG AND

MAKE and MODEL OF CAR	SYSTEM	IGNITION		GENERATOR		MOTOR	
		Make	Control	Make	Voltage	Make	Voltage
Peerless, Ser. 6....	Single	At-Kent.	H & A	A-L	6	A-L	6
Piedmont, 6-40....	Single	Remy	Hand	Remy	6	Remy	6
Pierce-Arrow, 38 and 48..........	Double	Delco	H & A	West	6-8	West	6
Pilot, 6-45.............	Dual	Delco	Hand	Delco	6	Delco	6
Porter, 46.............	Dual	Berling	Hand	West	12	West	12
Premier, 6-D........	Single	Delco	Hand	Delco	6	Delco	6
Reo, T and U.......	Single	North East	Hand	North East	6	North East	6
Reo, T6 and U6...	Single	North East	Hand	North East	6	North East	6
Revere..................	Single	Bosch	Hand	West	6	West	6
Roamer, 6-54........	Single	Bosch	Hand	Bijur	6	Bijur	6
R. & V Knight, J. & R...............	Dual	Wagner	Hand	Wagner	6	Wagner	6
Saxon, 125............	Single	Remy	Hand	Wagner	6	Wagner	6
Sayer, C. P...........	Single	Delco	Hand	Delco	6	Delco	6
Scripps-Booth, B	Single	Remy	Hand	Remy	6	Remy	6
Seneca, L.............	Single	Conn.	Hand	Allis Chal.	6	Allis Chal.	
Singer, 20............	Single	Bosch	Hand	West	6	West	6
Skelton..................	....	Conn.	Hand	West	6	West	6
Spaeke, S-20........	....	....	....	....	....	....	....
Standard, 8-I.......	Double	Dixie	Hand	West	6	West	6
Stanley, 735..........	....	....	....	Remy	6	....	....
Stearns, SKL-4....	Single	At-Kent.	Hand	West	12	West	12
Stephens, 80.........	Single	Conn.	Hand	A-L	6	A-L	6
Stevens-Duryea...	....	....	....	....	....	....	....
Studebaker, All...	Single	Wagner	Hand	Wagner	6-8	Wagner	6
Stutz, H................	Double	....	Hand	Remy	6	Remy	6
Templar, 445........	Single	Simms	Hand	Bijur	6	Bijur	6
Tulsa, E................	Single	Delco	Hand	Dyneto	6	Dyneto	6
Velie, 34................	Single	At-Kent.	H & A	West	6	West	6
Velie, 48................	Single	At-Kent.	....	Bijur	6	Bijur	6
Westcott, C-38 and 48................	Single	Delco	H & A	Delco	6	Delco	6
Willys-Knight, 02........................	Single	Conn.	Hand	A-L	6-8	A-L	6
Winther, 61..........	Single	West	Hand	West	6	West	6
Winton, 24...........	Single	Bosch	Hand	Bijur	6	Bijur	6
Winton, 25...........	Single	Bosch	Hand	Bijur	6	Bijur	6

ABBREVIATIONS: * Starting and Lighting in closed models only. Ignition: *At-K*, Atwater-Kent; *Conn.*, Connecticut; *West*, Westinghouse; *Auto*, Automatic; *H. & A*, Hand and Automatic; *S. A.*, Semi-Automatic. Generator: *A-L*, Auto-Lite; *G & D*, Gray & Davis; *Leece-N*, Leece-Neville; *Ward-L.*, Ward-Leonard; *N. E.*, North East; *Split*, Splitdorf. Motor: *A-L*, Auto-Lite, *G & D*, Gray & Davis; *Leece-N*, Leece-Neville; *West*, Westinghouse.

of 1920 Cars—Concluded

HORN EQUIPMENT, see pages 558 and 559

	BATTERY					FUSES		
MAKE and MODEL OF CAR	Make	Amp. Hr.	Voltage	Wiring System	Type of Electric System	Type	Volts	Amp
Peerless, Ser. 6	Willard	......	6	1	....	....	......	....
Piedmont, 6-40	Willard	90	6	1	S	....	......	....
Pierce-Arrow, 38 & 48	Willard	150	6	1	S	5A.G.	6-8	....
Pilot, 6-45	Prest-O-L	80	6	1	GI	....	......	....
Porter, 47	Prest-O-L	118	12	1	S	Cart.	12	....
Premier, 6-D	Willard	123.5	6	1	S	....	......	....
Reo, T & U	Willard	108.5	6	2	GI	Wire	6	5
Reo, T6 & U 6	Willard	108.5	6	1	S	Wire	6	6
Revere	Willard	120	6	1	S	GT	6	15
Roamer, 6-54	Columbia	117	6	1	S	3A	6	10
R & V Knight, J & R	Willard	117	6	1	S	Cart.	250	20
Saxon, 126	Prest-O-L	80	6	1	S	Cart.	6-8	15
Sayers, C. P.	Willard	80	6	1	GI	CB	......	....
Scripps-Booth, B	Prest-O-L	85	6	1	GI	GT	6	20
Seneca, L	Prest-O-L	88	6	1	GM	....	......	20
Singer, 20	Willard	115	6	1	S	GC	......	5 & 10
Skelton, 35	Prest-O-L	85	6	1	....	....	......	....
Spacke, S-20	....	......	....	....	....	....	......	....
Standard, 8-I	Willard	160	6	1	SW	2A	6	15
Stanley, 736	Willard	100	6	1	G	Cart.	6	20
Stearns, SKL-4	Willard	61.5	12	1	S	Cart.	6	20
Stephens, 80	U. S. L.	116	6	1	S	....	6	20
Stevens-Duryea	....	......	....	....	....	....	......	....
Studebaker, All	Willard	115	6-8	1	S	Cart.	6	10
Stutz, H	Willard	......	12	1	S	....	......	20
Templar, 645	Columbia	100	6	1	S		6	20
Tulsa	Exide	90	6	1	S	GT	6	15
Velie, 34	Willard	100	6	....	....	....	......	....
Velie, 48	Willard	120	6	1	S	Wire	......	15
Westcott, C-38 & 48	Willard	120	6	1	S	CB	......	....
Willys-Knight, 20	U. S. L.	170	6	1	GI	GT	6	20
Winther, 61	Willard	127	6	....	S	GI	6	10
Winton, 24	Willard	120	6		S	GT	6	15
Winton, 25	Willard	139	6	1	S	CB	6	15

Battery: *Prest-O-L,* Prest-O-Lite. Wiring system: *GI,* Generator and Ignition combined; *GIM,* Generator, Ignition, Motor combined; *S,* Generator, Motor Ignition separate; *GM,* Generator and Motor combined. Fuses: *GT,* Glass Tube: *Cart,* Cartridge; *C. B.,* Circuit Breaker. Lamps: * Dashlights in series with taillights; headlight contains sidelight; d,—double contact; s,—single contact.

Electrical Equipment

FOR IGNITION, GENERATOR, MOTOR,

		LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE							
		HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
MAKE and MODEL OF CAR	Contact	Volts	CP.	lVots	CP.	Volts	CP.	Volts	CP.
Allen 43	Single	6—8	18	*6—8	2	6—8	2	6—8	2
American B	Single	6—8	15	*6—8	5	3—4	2	3—4	2
Anderson All	Single	6—8	21	6—8	4	6—8	4	6—8	4
Apperson All	Double	6—8	18	*6—8	4	d6—8	2	d6—8	2
Argonne	Single	12	21	12	6	12	2	12	2
Auburn 6-39	Single	6—8	15	*6—8	4	6—8	2	6—8	2
Beggs 19-T & 19-R	Single	6—8	21	6—8	4	3—4	2	3—4	2
Biddle B-1 & B-5	Single	6—8	21	*6—8	4	6—8	2	d6—8	2
Bour-Davis 20	Single	6—8	15	6—8	5	6—8	2	6—8	2
Brewster	Single	12	36	12	4	6—8	2	d6—8	2
Briscoe	Single	6—8	21	......	......	6—8	2	d6—8	2
Buick	Single	6—8	15	6—8	4	6—8	2	6—8	2
Cadillac 57	Single	7	18	8	6	4	2	3—4	2
Case V-20	Single	6—8	21	6—8	4	6—8	2	6—8	2
Chalmers 35-C	Single	6—8	15	*6—8	4	6—8	2	6—8	2
Champion KO	Single	6—8	15	......	......	6—8	2	6—8	2
Chandler All	Single	6—8	15	6—8	4	6—8	2	6—8	2
Chevrolet All	Single	6—8	21	6—8	4	6—8	2	d6—8	2
Cleveland 40	Single	6—8	17	6—8	4	6—8	2	6—8	2
Cole All	Single	6—8	21	*6—8	5	6—8	4	d6—8	2
Columbia All	Single	6—8	15	*6—8	4	6—8	2	d6—8	2
Comet C-53	Single	6—8	18	......	......	6—8	2	6—8	4
Crow-Elkert L-55	Single	6—8	15	6—8	4	6—8	2	6—8	2
Cunningham V-3	Single	6—8	21	6—8	4	6—8	2	6—8	2
Daniels 8-D	Single	6—8	21	6—8	4	6—8	2	d6—8	2
Davis 51	Single	6—8	21	......	......	6—8	2	6—8	2
Dixie Flyer	Double	6—8	15	......	......	d3—4	2	d3—4	2
Dodge Brothers	Single	12—16	15	......	......	12—16	2	12—16	2
Dorris 6-80	Single	6—8	21	6—8	4	6—8	2	6—8	2
Dort 15	Single	6—8	15	......	......	6—8	2	d6—8	2
du Pont A	Single	6—8	21	6—8	4	6—8	2	6—8	2
Economy 6-46	Single	......	....	......	......	......	......	......	....
Elcar All	Single	6—8	21	6—8	4	6—8	2	6—8	2
Elgin K	Single	6—8	17	......	......	6—8	2	6—8	2
Essex A	Single	6—8	15	......	......	3—4	2	*3—4	2
Ferris	......	......	....	......	......	......	......	......	....
Ford T*	Double	6—8	17	6—8	2	6—8	2	......	....
Franklin 9-B	Double	12—16	21	*12—16	4	6—8	2	6—8	2
Gardner O	Single	6—8	15	......	......	6—8	2	6—8	2
Geronimo	Single	6—8	21	......	......	6—8	2	6—8	2
Grant H	Single	6—8	15	6—8	4	6—8	2	6—8	2
Hanson 45-A	Single	6—8	15	......	......	6—8	2	6—8	2
Harroun	Single	6—8	15	......	......	3—4	2	d3—4	2
Harvard 4-20	......	6—8	....	3—4	......	3—4	......	*3—4	....
Hatfield A	Single	6—8	15	*4—8	4	6—8	4	6—8	2
Haynes All	Double	6—8	15	*6—8	12	d6—8	2	6—8	2
H. C. S. Special	......	......	....	......	......	......	......	......	....
Hollier 206-B	Single	6—8	15	6	4	3—4	2	3—4	2
Holmes	Double	12—16	30	......	......	6—8	2	6—8	2
Hudson Super-Six	Single	6—8	15	6—8	4	3—4	2	*3—4	2
Huffman	......	......	....	......	......	......	......	......	....
Hupmobile R	Single	6—8	18	*6—8	5	6—8	2	6—8	2

of 1920 Cars

BATTERY AND FUSE EQUIPMENT, see pages 554 and 555

MAKE and MODEL OF CAR	SPARK PLUGS Make	Diam. Inches	Thread Pitch	HORN
Allen 43	Champion	⅞	18	Klaxon
American B	Bethlehem	⅞	18	Sparton
Anderson All	A. C.	⅞	18	Klaxon
Apperson All	A. C.	⅞	18	Sparton
Argonne 4	A. C.	⅞	18	Klaxon
Auburn 6-39	Rajah	⅞	18	E. A.
Beggs 19-T & 19-R	Champion	⅞	18	Trojan
Biddle B-1 & B-5	Splitworf	⅞	18	Klaxon
Bour-Davis 20	A. C.	⅞	18	E. A.
Brewster	Herz-Boug	⅞	18	Klaxon
Briscoe 4-34	Champion	⅞	18	Sparton
Buick	A. C.	⅞	18	Stewart
Cadillac 57	Titan	⅞	18	Delco
Case V-20	A. C.	⅞	18	Klaxon
Chalmers 35-C	A. C.	⅞	18	Schwarze
Champion KO	Champion	⅞	18	Garford
Chandler All	A. C.	⅞	18	Klaxon
Chevrolet All	A. C.	⅞	18	Klaxon
Cleveland 40	A. C.	⅞	18	Trojan
Cole All	A. C.	⅞	18	Sparton
Columbia All	Champion	⅞	18	Schwarze
Comet C-53	Champion	⅞	18	Klaxon
Crow-Elkhart L-55	Champion	⅞	18	E. A. Lab.
Cunningham V-3	Champion	⅞	18	Sparton
Daniels 8-D	A. C.	⅞	18	Klaxon
Davis 51	A. C.	⅞	18	Klaxon
Dixie Flyer	Champion	⅞	18	Garford
Dodge Brothers	A. C.	⅞	18	Klaxon
Dorris	Opt.	⅞	18	Klaxon
Dort	A. C.	⅞	18	Schwarze
du Pont A	A. C.	⅞	18	Klaxon
Economy 6-46	....	....	....	....
Elcar All	Champion	⅞	18	1. A. L.
Elgin K	Champion	⅞	18	1. A. L.
Essex A	A. C.	18 m. m.	1.5 m. m.	Sparton
Ferris	....	....	....	....
Ford T	Champion	½	pipe	Own
Franklin 9-B	Opt	⅞	18	Klaxon
Gardner G	Champion	⅞	18	Trojan
Geronimo	Champion	⅞	18	Trojan
Grant H	Champion	⅞	18	Trojan
Hanson 45-A	Champion	⅞	18	Schwarze
Harroun	A. C.	....	....	Schwarze
Harvard 4-20	....	⅞	18	....
Hatfield A	A. C.	⅞	18	Ecco
Haynes All	A. C.	⅞	18	Klaxon
H. C. S. Special	....	....	....	....
Hollier 206-B	A. C.	⅞	18	Sparton
Holmes	Bethlehem	⅞	18	Klaxon
Hudson Super Six	A. C.	⅞	18	Sparton
Huffman	....	....	....	....
Hupmobile R	A. C	⅞	18	Trojan

Electrical Equipment

FOR IGNITION, GENERATOR, MOTOR,

MAKE and MODEL OF CAR	Contact	LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE							
		HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
		Volts	CP.	lVots	CP.	Volts	CP.	Volts	CP.
Jackson 6-38	Single	6—8	15	6—8	4	3—4	2	3—4	2
Jones All	Double	6—8	15	*6—8	4	s6—8	2	s6—8	2
Jordan F	Single	6—8	18	*6—8	4	6—8	3	6—8	3
Jordan M	Single	6—8	18	6—8	4	6—8	3	6—8	3
King 8	Single	6—8	15	*6—8	4	6—8	2	6—8	2
Kissel	Double	6—8	18	......	......	d6—8	2	d6—8	2
Kline 6-55-J	Single	6—8	15	......	......	6—8	2	d6—8	2
LaFayette	....	6—8	21	6—8	6	3—4	4	3—4	2
Leach	....	....	....	......	......	....	......	....	....
Lexington S-20	Single	6—8	21	6—8	4	6—8	2	d6—8	4
Liberty 10-C	Single	6—8	15	*6—8	4	6—8	2	d6—8	2
Locomobile 48-6-7	Single	6—8	21	6—8	6	6—8	4	6—8	2
Lorraine	Single	6—8	17	......	......	6—8	2	6—8	2
Maibohm B	Single	6—8	20	6—8	4	6—8	2	6—8	2
Marmon 34	Single	6—8	30	*6—8	9	6—8	2	6—8	2
Maxwell 25	Double	12—16	15	*12—16	4	12—16	2	12—16	2
McFarlan 127	Single	6—8	21	*6—8	12	6—8	2	d6—8	2
Mercer Ser. 5	Single	6—8	21	6—8	5	6—8	5	6—8	4
Meteor K R	Single	6—8	....	6—8	......	6—8	......	6—8	....
Metz, Master Six	Single	6—8	16	6—8	4	6....8	2	6—8	2
Mitchell F-40	Single	6—8	15	......	......	s6—8	2	6—8	2
Monitor	....	....	....	......	......	....	......	....	....
Monroe S-9	Double	6—8	16	......	......	6—8	2	6—8	2
Moon 6-48	Single	6—8	20	......	......	6—8	2	d6—8	2
Moon 6-68	....	6—8	20	......	......	6—8	2	d6—8	2
Moore F	Single	6—8	20	6—8	......	6—8	2	....	....
Nash	Single	6—8	16	*6—8	4	6—8	2	d6—8	2
National Series BB	....	6—8	20	*6—8	4	6—8	2	6—8	2
Nelson D	Double	12—16	15	12—16	4	12—16	2	12—16	2
Noma 1-B	Single	6—8	....	......	......	6—8	......	d6—8	....
Oakland 34-B	Single	6—8	15	......	......	6—8	2	6—8	2
Ogren 6-60	Single	6	32	6	......	6	4	6	4
Oldsmobile 37-A	Single	6—8	15	6—8	4	6—8	2	6—8	2
Oldsmobile 45-B	Single	6—8	15	*6—8	4	6—8	2	6—8	2
Olympian 45	....	....	....	......	......	....	......	....	....
Overland 4	Single	6—8	16	......	......	3—4	2	*3—4	2
Packard 3-35	Single	6—8	33	*6—8	4	6—8	2	6—8	2
Paige All	Single	6—8	17	6—8	4	6—8	2	d6—8	2
Pan-American All	Single	6—8	32	......	......	6—8	2	*3—4	4
Paterson 6-47	Single	6—8	15	6—8	4	6—8	2	6—8	2
Peerless Ser. 6	Single	6—8	15	6—8	......	6—8	2	6—8	4
Piedmont 4-30	Single	6—8	12	......	......	6	2	6	2
Piedmont 6-40	Single	6—8	12	......	......	6	2	6	2
Pierce-Arrow 38&4'	Single	6—8	20	......	......	6—8	5	6—8	5
Pilot 6-45	Single	6—8	15	......	......	6—8	2	6—8	2
Porter 46	Single	12—16	20	12—16	4	12—16	4	12—16	2
Premier 6	Double	6—8	21	*6—8	4	6—8	2	d6—8	2
Reo T & U	Double	6—8	15	......	......	3—4	2	*3—4	2
Reo T6 & U6	Single	6—8	15	......	......	6	2	*3—4	2
Revere	Single	6—8	20	*6—8	8	6—8	4	6—8	4
Roamer 6-54	Single	6—8	15	*6—8	2	6—8	2	d6—8	2
R & V Knight J & I	Single	6—8	15	6—8	4	6—8	2	d6—8	4

of 1920 Cars—Continued

BATTERY AND FUSE EQUIPMENT see pages 554 and 555

MAKE and MODEL OF CAR	SPARK PLUGS Make	Diam. Inches	Thread Pitch	HORN
Jackson 6-38	Champion	⅞	18	Stewart
Jones	Champion	⅞	18	Newtone
Jordan F	A. C.	⅞	18	Sparton
Jordan M	A. C.	⅞	18	Sparton
King 8	Champion	⅞	18	Sparton
Kissel	A. C.	⅞	18	Sparton
Kline 6-55-J	Champion	⅞	18	Klaxon
Lafayette	....	⅞	18	Klaxon
Leach	....	....	....	....
Lexington S-20	Bethlehem	⅞	18	E. A. L.
Liberty 10-C	A. C.	⅞	18	United
Locomobile 48-6-7	Titan	⅞	18	Klaxon
Lorraine	A. C.	⅞	18	Schwarze
Maibohm B	Champion	⅞	18	Schwarze
Marmon 34	A. C.	⅞	18	Sparton
Maxwell 25	Champion	⅞	18	Schwarze
McFarlan 127	A. C.	⅞	18	Klaxon
Mercer Ser. 5	Champion	⅞	18	Sparton
Meteor K R	....	....	....	....
Metz, Master Six	Champion	⅞	18	Trojan
Mitchell F-40	A. C.	⅞	18	Sparton
Monitor	Champion	⅞	18	Klaxon
Monroe S-9	Champion	⅞	18	Trojan
Moon 6-48	Champion	⅞	18	Klaxon
Moon 6-68	Champion	⅞	18	Klaxon
Moore F	Champion	⅞	18	Garford
Nash	A. C.	⅞	18	Trojan
National Series BB	A. C.	⅞	18	Sparton
Nelson D	Champion	⅞	18	Schwarze
Noma 1-B	....	....	....	....
Oakland 34-B	A. C.	⅞	18	Schwarze
Ogren 6-60	Champion	⅞	18	Klaxon
Oldsmobile 37-A	A. C.	⅞	18	Klaxon
Oldsmobile 45-B	A. C.	⅞	18	Klaxon
Olympian 45	Champion	....	....	E. A. Lab.
Overland 4	Champion	½	....	A. L.
Packard 3-35	A. C.	⅞	18	Sparton
Paige All	A. C.	⅞	18	Trojan
Pan-American All	Champion	⅞	18	E. A. Lab.
Paterson 6-47	A. C.	....	18	E. A. Lab.
Peerless Ser. 6	A. C.	....	18	Sparton
Piedmont 4-30	Champion	⅞	18	Klaxon
Piedmont 6-40	Champion	⅞	18	Klaxon
Pierce-Arrow 38 & 40	A. C.	⅞	18	Klaxon
Pilot 6-45	A. C.	⅞	18	Schwarze
Porter 46	Champion	....	18	Stewart
Premier 6	A. C.	⅞	18	Klaxon
Reo T & U	A. C.	⅞	18	Trojan
Reo T6 & U6	A. C.	½	....	Klaxon
Revere	Rajah	⅞	18	Klaxon
Roamer 6-54	A. C.	⅞	18	Sparton
R & V Knight J & R	A. C.	⅞	18	Klaxon

Electrical Equipment

FOR IGNITION, GENERATOR, MOTOR,

MAKE and MODEL OF CAR	Contact	LAMP CANDLEPOWER, VOLTAGE AND TYPE OF BASE							
		HEAD-LIGHTS		SIDE-LIGHTS		TAIL-LIGHTS		DASH-LIGHTS	
		Volts	CP.	1Vots	CP.	Volts	CP.	Volts	CP.
Saxon 125	Single	6—8	15	......	......	6—8	2	6—8	2
Sayers C. P.	Single	6—8	15	......	......	6—8	2	d6—8	2
Scripps-Booth B	Single	6—8	15	......	......	6—8	2	6—8	2
Seneca H-2	Single	6—8	15	6—8	2	6—8	2	d6—8	2
Singer 2C	Single	6—8	15	......	4	6—8	2	d6—8	2
Skelton 35	....	6	18	......	......	6	2	6	2
Spacke S-2C	....	....	....	......	......	....	......	....	....
Standard 8-I	Double	6—8	21	6—8	4	6—8	2	6—8	2
Stanley 735	Double	6—8	21	6—8	4	6—8	2	6—8	2
Stearns SKL-4	Single	12—16	21	*12—16	4	12—16	2	12—16	2
Stephens 8C	Single	6—8	15	6—8	2	6—8	2	6—8	2
Stevens-Duryea	....	....	....	......	......	....	......	....	....
Studebaker All	Single	6—8	12	......	......	6—8	2	6—8	2
Stutz H	Double	6—8	15	*6—8	4	6—8	2	6—8	2
Templar 445	Single	6—8	21	*6—8	4	6—8	2	6—8	2
Tulsa E-1, 2, 3	Single	6—8	21	6—8	2	6—8	2	d6—8	2
Velie 48	Single	6—8	15	6—8	4.	6—8	4	d6—8	4
Westcott C-38&C-4	Single	6—8	18	*6—8	4	3—4	2	d3—4	2
Willys-Knight 2C	Single	6—8	30	6	6	3—4	2	3—4	2
Winton Six 24	Single	6—8	17	6—8	7	6—8	2	6—8	2
Winton Six 25	Single	6—8	17	6—8	7	6—8	2	6—8	2
Winther 61	Single	6	18	......	......	6	4	6	2

ABBREVIATIONS: * Starting and Lighting in closed models only. Ignition: *At-K*, Atwater-Kent; *Conn.*, Connecticut; *West*, Westinghouse; *Auto*, Automatic; *H. & A*, Hand and Automatic; *S. A.*, Semi-Automatic. Generator: *A-L*, Auto-Lite; *G & D*, Gray & Davis; *Leece-N*, Leece-Neville; *Ward-L.*, Ward-Leonard; *N. E.*, North East; *Split*, Splitdorf. Motor: *A-L*, Auto-Lite, *G & D*, Gray & Davis; *Leece-N*, Leece-Neville; *West*, Westinghouse.

of 1920 Cars—Concluded

BATTERY AND FUSE EQUIPMENT, see pages 554 and 555

MAKE and MODEL OF CAR		SPARK PLUGS		
	Make	Diam. Inches	Thread Pitch	HORN
Saxon 125	A. C.	⅞	18	Trojan
Sayers C. P	Champion	⅞	18	Stewart
Scripps-Booth B	A. C.	⅞	18	Opt
Seneca H-2	A. C.	⅞	18	Fitzgerald
Singer 20	A. C.	⅞	18	Klaxon
Skelton 35	Bethlehem	⅞	18	E. A. Lab.
Spacke S-20		....	....	....
Standard 8-I	A. C.	⅞	18	Klaxon
Stanley 735		....	....	Klaxon
Stearns SKL-4	A. C.	⅞	18	B. & A. Lab.
Stephens 80	Champion	⅞	18	Trojan
Stevens-Duryea		....	....	....
Studebaker All	Champion	½	....	Sparton
Stutz H	A. C.	....	....	Klaxon
Templar 445	Champion	⅞	....	Klaxon
Tulsa E-1, 2, 3	Champion	⅞	18	Trojan
Velie 48	Champion	⅞	18	Sparton
Westcott C-38&C-48	A. C.	⅞	18	Klaxon
Willys-Knight 20	Champion	....	....	Sparton
Winton Six 24	Champion	⅞	18	American
Winton Six 25	Champion	⅞	18	Electric
Winther 61	A. C.	⅞	18	Klaxon

Battery: *Prest-O-L,* Prest-O-Lite. **Wiring system:** *GI,* Generator and Ignition combined; *GIM,* Generator, Ignition, Motor combined; *S,* Generator, Motor Ignition separate; *GM,* Generator and Motor combined. **Fuses:** *GT,* Glass Tube: *Cart,* Cartridge; *C. B.,* Circuit Breaker. **Lamps:** * Dashlights in series with taillights; headlight contains sidelight; d,—double contact; s,—single contact.

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